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THESE PAPERS ARE FROM THE BRAILLE RESEARCH AND DEVELOPMENT CONFERENCE SPONSORED BY THE SENSORY AIDS EVALUATION DEVELOPMENT CENTER ON NOVEMBER 18, 1966. THE PAPERS PRESENTED ARE--"A STUDY OF BRAILLE PRODUCTION, DISTRIBUTION, AND USE," BY LOUIS GOLDISH, "AUTOMATED BRAILLE AND THE PROFESSION OF PROGRAMMING FOR THE BLIND," BY THEODOR D. STERLING, "BRAILLETRAN--A COMPREHENSIVE BRAILLE TRANSCRIPTION PROGRAM," BY JOHN J. BOYER, "SMALL COMPUTERS AND GRADE TWO BRAILLE," (SUMMARY) BY EDWARD L. GLASER, "ON READING AND READING BRAILLE," BY A. P. BRUNWALD, "COMPUTER TRANSLATION OF GRADE TWO BRAILLE," BY ROBERT HAYNES, "BRAILLE RESEARCH AT GEORGE PEABODY COLLEGE," BY RICHARD W. WOODCOCK, "THE EFFECTS OF PATTERN COMPLEXITY AND REDUNDANCY ON THE TACTUAL RECOGNITION OF METRIC FIGURES," BY EMERSON FOULKE AND JOEL WARM, "COMPUTER PROGRAMMING AND THE BLIND, "BY DONALD BISHOP, "COMPUTER PRODUCTION OF BRAILLE AT THE ROYAL NATIONAL INSTITUTE FOR THE BLIND," BY CLIVE WINDEBANK, "COMPUTER CONVERSION OF COMPOSITORS TAPES TO GRADE TWO BRAILLE," BY ANN AND JOSEPH SCHACK, "BRAILLE EMBOSSER AND DISPLAY SYSTEMS," BY DWIGHT M. BAUMANN, AND "ADVANCES IN BRAILLE EMBOSSING," BY RAY E. MORRISON. TABLES, FIGURES, AND REFERENCES ACCOMPANY SOME OF THE PRESENTATIONS. A LIST OF CONFERENCE PARTICIPANTS IS INCLUDED. (CG)

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PROCEEDINGS

BRAILLE RESEARCH AND DEVELOPMENT CONFERENCE

sponsored by the

SENSORY AIDS EVALUATION AND DEVELOPMENT CENTER, M.I.T.

M.I.T. FACULTY CLUB

Friday, 18 November 1966

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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A STUDY OF BRAILLE PRODUCTION, DISTRIBUTION, AND USE

Louis Goldish

Since it is not possible here to go into all the details that will be contained in my thesis, I would rather just give a rough outline of what it will contain.

Purpose of the Study

One might ask why is this study being made and why is the study of the market so important. Let us say we were in the consumer appliance business, and we came up with a rather radical idea; for example, let us put newspapers on microfilm and have people read them at home on microfilm readers, so that we can get rid of bulky newspapers. We would probably want to do a fairly good market survey to find out who would want such a system, whether it would sell, how much people would be willing to pay for it, and other details.

We, here at the Braille Conference, are trying to do just that - we're trying to introduce new ideas into a century-old Braille production system. The Braille market and the Braille production system are characterized by diverse needs, limited finances, and many social, political, and emotional factors. Many of the concepts we have come up with to institute into this system are complex and expensive, and many may require extensive changes in the Braille production system or in some of its organizations.

The success of our developments, no matter how efficient or technologically capable they may be, will ultimately depend on how the market accepts them. For example, with the microfilm reader idea, people might be more willing to spend ten cents and run the risk of dunking their newspapers into the morning coffee than to spend a dollar to get a nice compact system. Also, just the very idea of having to equip each home in the United States with a microfilm reader would take considerable effort in itself.

On the same tack, we might ask ourselves just how many people would want to use a $1,500 Braille embosser. Thus, we must study the market to find out what changes are needed, can the changes be made, and what we can we do so that efficient and economical Braille production will result. Economical production is just as important as efficient production; we do not want to price ourselves right out of the market.

Scope of the Report

As far as the scope of the report is concerned, it will be an overall view of Braille use, production and distribution. It is being written to appeal to four groups of people. First is the insider in the Braille production system; he wants to know what is the overall market for Braille, what devices are available, what is the cost of these devices, and what is the direction that research is taking. The second group the report is aimed at is the new entries into the Braille production system who, let us say, are just entering one of your organizations. The report will give them some background and insight into the way the Braille production and distribution system works. The third group is the interested layman who wants to find out what the Braille production system is like. Those groups, such as the government, concerned with financing Braille production, can learn something of the system with which they are concerned. And, lastly, the report is aimed at a very important group - the technically oriented people - who might want to help by building devices or by giving ideas for Braille production devices, but who are not quite sure exactly what the market is for such devices, who would use them, and what the major problem areas are which need research.

Contents of Report

The first chapter covers Braille - its uses and its problems - including the need for Braille, why it cannot be completely replaced by talking books, who uses it, and for what purposes. It is remarkable how few people know that Braille being used today does not have a one-to-one correspondence with English. Even some of the people that are building devices have very little idea of the difficulties entailed in producing Grade 2 Braille. Therefore, the report contains a brief description of the complexities of the Grade 2 Braille code.

This chapter also covers systemic problems in Braille - problems arising from the general nature of the Braille system. The first problem area is transcription complexities, the fact that Braille requires skilled braillists, and that what is needed is either to make it easier for someone to learn correct Braille or to make it easier for someone with less skill to produce accurate Braille.

The second problem area is production - how can the output of Braille be speeded up. We know that present Braille transcription is very slow, and that anything we can do to increase the speed of transcription would be very helpful.

The third problem area is distribution - trying to get the books from where they are made to where they are read. This is quite a problem, and at present takes a long time.

Finally, there are storage and display problems. A Braille library now takes a very large amount of space to store even a moderate number of volumes. Perhaps as some people have suggested, it might be advisable to place some of the volumes on punched paper tape, especially those that are not very widely circulated, and to print one out on throw-away-type copy every time a request comes in, rather than having to store heavy, rugged books produced for library copy.

The second chapter, which will be covered in more detail later, is concerned with the market for Braille. First covered is the blind market -

essentially, who are the blind market, how is it growing, and what are the trends in it. Then, the size of the Braille market, who actually reads Braille, and finally the characteristics of this market - the economic and social characteristics of the people in it.

Chapter three covers the sources of Braille - the producers, braillists, braillists groups, Braille presses and publishers - in order to give some indication as to their output and the problems they encounter. Also covered is Braille book source information - the union catalogs and both public and private clearing houses and libraries.

The fourth chapter contains the method and costs of producing Braille. This includes a model of the Braille production and distribution system to explain exactly how the flow of material is maintained through the system, and also a discussion of the present production methods both for hand produced copy and for press Braille.

Chapter five contains the technological advances in Braille, including a compendium of the advances that have been made in the Braille production-distribution system, the devices, techniques, and computer programs. Information on these will include the type of personnel needed, the equipment needed, the costs of these devices, including producing costs, operating costs, and maintenance costs, special accommodations that will be needed for these new systems, and perhaps a few types of integrated system design.

The sixth chapter will cover the effects of innovation on Braille production. These will include the effects other than technical. For example, there are political aspects; if we have a centralized Braille production system, who will coordinate it and who will be in charge of operating the system as to indicating who performs which type of duties? There are social apsects; the braillist to Braille reader relationship is quite personal at present, and if we go to more automation there may be some changes in this. Finally, the economic aspect; Braille volunteers require little support, while Braille translating computers require quite a bit of support. Where will this money come from? This chapter will also cover the market for new devices. For example, how many high-speed braillers can be used? How many Braille translating computers can be used? Shall there be one in a central place, or a few small ones in distributed locations?

Lastly, the seventh chapter will contain recommendations, not necessarily for complete system design, but for considerations of the trade-offs that will be encountered in designing such systems.

Model of the Braille Production System

And now to cover in a little bit more detail some of the content of these chapters. For example, the model of the Braille system that has been developed is shown in here in exhibit I (exhibit one shown to group). This shows the various phases of input, production, and distribution in the Braille system, and what flows into and out of these various elements. Notice also that the system is contained in a political, economic and social environment. Under present conditions, each of these functions is usually taken care of by one group - either the Braille press or the braillist volunteer group. However, for easier study of new devices, the model is helpful because many of these functions can be separated. For example, input devices might be tape punches or card punchers located quite remotely from the place where the production or translation is actually accomplished. The production function might be carried out by one main computer or a bunch of little computers, either of which can be considered separately. And finally, the distribution function may be performed by remote braillers, by libraries, or by mail-order houses, each of which can be studied separately. Breaking the system up this way also makes for easier cost analysis for each of the elements of the Braille production and distribution system.

The Market for Braille

One of the very detailed studies in the report is the market for Braille; who uses it, who reads it, and who might take advantage of the new devices available. Of the major statistics on the blind are Dr. Hurlin's analyses of the total blind in the country, in which he says that at present there are approximately 400,000 legally blind in the United States. The systems under concern, however, are considered mainly with the actual people who read Braille. The percentage break-down of Braille readers in the legally blind populations are shown in exhibit 2 (exhibit 2 shown to group). Notice that those 65 and over comprise almost half of the legally blind in this country. Analysis of the figures indicates that approximately 40,000 people in this country read Braille and approximately 33,000 use it actively. Therefore, in designing any Braille production-distribution system, we must consider the fact that our market is not that large. First, we should not design a system that will cost too much to be supported by 33,000 people, and second, we should not make it have so much excess capacity that a good portion of it will never be used.

Exhibit 3 (exhibit 3 shown to group) shows the market segmentation of the Braille readers, including the numbers in each segment, their requirements, their economic status, and predicted growth or changes in each of these segments. The movement of those suffering from retrolental fibro plasia provides a very important consideration for the Braille market, because we must neither over-plan nor under-plan for them. We must know that they are moving through the system. It should be noted that, while the number of blind will probably grow approximately as the general population, the increased use of recorded material plus the various difficulties involved in reading and obtaining Braille will probably decrease the actual percentage of Braille readers among the legally blind. Also, the trend toward sight utilization, rather than sight preservation, will further decrease the absolute percentages of Braille readers among the legally blind.

The active market for Braille in the next ten years will probably consist of approximately 50,000 readers, with the major demands being for elementary school textbooks, secondary school textbooks and college texts, as well as current reading material. The number of aged blind and their percentage will probably grow as blindness becomes increasingly an "old age disease". The low propensity of this group for learning Braille and for using it indicates that we should not work with absolute figures of the blind but with the actual number of Braille readers. The bulk of the retrolentals are presently moving through highschool and will be entering college shortly, so that we do know there will be a large demand in this segment soon, and in a few years hence their demand will be felt in the professional-and-business-material category.

Conclusion

While no detailed statistics are given in this description, the actual report does contain rather extensive statistics on the market, on Braille readers, on Braille producers, and on the Braille system, as well as the descriptions of devices, procedures, and their costs.

The major service to be performed by this report is that we must know that we must give good consideration to the devices we are developing. Consider their costs, their uses, their probable market, their maintenance and reliability, their impact on the Braille market, and the problems we may have in getting some of our devices accepted. We must be realistic and look at our devices not only from the technical point of view, but also from a point of view of a reader who is going to use these devices and from one who must financially support this system. While the devices may be technologically excellent, if they cannot be accepted by the consumer they have no value.

In the consumer market, a company which has come out with a poor product can take a loss "this time" and make it up in profits the next. In the Braille business, we have no profits that we can afford to lose. We need all the money we can get and we must give as good service as we possibly can. Therefore, an extensive study of what is being done before a great deal of money is spent on implementing it will make it easier to insure that economic and efficient Braille production will result from our present efforts.

AUTOMATED BRAILLE AND THE PROFESSION OF PROGRAMMING FOR THE BLIND

Dr. Theodor D. Sterling

Recent years have seen a phenomenal growth of professional opportunities for qualified blind persons in occupations related to programming computers. Many heretofore "under employed" and also "under trained" blind persons have been able to participate in the development and execution of procedures to solve business and scientific problems using high speed processors. The interesting earmark of this growth has been that it was made possible, almost overnight, by the invention of techniques that lead to rapid communications between the computer and the blind programmer by embossing in readable Braille all of the many voluminous communications of the machine to the programmer or user. The embossing is done by the same high speed printer that is a routine peripheral device for most computers.

Prior to 1962, a very small number of highly motivated and able blind individuals managed to gain a foothold in the computing profession. Bauman and Yoder(1) find three programmers employed in the industry during that year. These individuals had to rely heavily upon the good offices of colleagues, clerks, and others to mediate constantly between their needs and their ability to read large amounts of computer generated printouts. Prior examinations of this field by rehabilitation specialists had led to relative negative conclusions concerning the ability of this profession to absorb large numbers of blind trainees. The major obstacle facing the potential programmer who is blind was that work with computers required reading of voluminous materials produced by the processor during the development of any programming system.

Most of the job of a programmer consisted not of writing a program (which a blind person could certainly learn to do without undue difficulty) but in debugging it afterwards. In this process (which may and usually does require between five to forty runs on the machine) the programmer attempts to assemble his program on the computer and receives, in turn, voluminous output which he has to study carefully and which he uses to find errors and unsuitable statements in the program. After the program has been assembled, there is still a need to check the accuracy of results and study printouts of partial computations, contents of the memory, and so on. It was obvious that unless a blind person would have quick access to translation in a form suitable to him, he could not participate in this type of work.

In 1963, work was done at the University of Cincinnati to utilize the high speed printer for the production of readable embossed Braille. It turned out that a simple method existed by which a readable Braille can be produced on the high speed printer without major modifications to the mechanism.

The high speed printer most frequently in use in the country is the 1403 printer designed and manufactured by the IBM Corporation. In this printer, a row of 132 hammers (the number may vary for different models) strike simultaneously against a rapidly revolving chain consisting of alphabetic, numeric, and other symbols. When the proper characters to be printed are opposite a hammer, it strikes against that letter, forcing a continuous strip of paper along. The impact between chain and hammer has sufficient force to produce as many as five or six carbon copies.

It turned out that by using a high pressure setting, an indentation could be made in the paper which could be felt by a blind person. By using proper back-up materials, this indentation can be enhanced. The two favorite back-up materials seem to be an inch wide strip of garter belt or a strip of corn plaster of the same width. The strips can be affixed permanently to the high speed printer without interfering with its operations. Of all the symbols on the print chain, the asterisk and period make the best indentation. These indentations result in a raised dot on the opposite side of the paper. While the resulting Braille is not as good as that produced by Perkins writer for instance, it is good enough to permit reading and will stay intact for a relatively long period of time.

Using this embossing quality of the high speed printer, programs can be written that translate the alphabetic and numeric characters usually produced by the printer into their Braille equivalents. This translation is done on the high speed processor as part of the assembly program so that the printer receives the proper impulses from its associated processor. Braille symbols are printed out (or embossed) in mirror image. The programmer then turns the paper to its opposite side and reads the raised dots as ordinary Braille.

The comprehensiveness with which translations of computer printout can be programmed and reformatted into Braille varies. A discussion of the process of producing Braille is given by Sterling et al. (4). A sophisticated translation and formatting system is described by Landwehr and McLaughlin (3) and a detailed job description and use of the embosser is described in a brochure circulated by the Association for Computing Machinery (2) and by a report of the Cincinnati project (5).

The ability to produce a communication in Braille between the computer and programmer removed in one action most of the obstacles between the blind individual and this profession. In essence, this high speed printer-processor combination represents perhaps the first reading machine in routine use. While it is true that a number of other aids were constructed to enable the blind programmer to extend his operations (such as a card reader or a console probe, which are described in (4)) these were of much smallerimpact on the profession.

After the doors for professional work were opened by providing the blind programmer with a fast and efficient reading machine, training and placement proceeded very rapidly. There are now a number of places in the country where training is given routinely so that each year 40 to 50 blind candidates are being prepared for work in this profession. Most of them find employment almost immediately. Using similar techniques, training and placement of blind programmers is done with equal success in Canada, England, Holland and Israel.

It is noteworthy that the embossing qualities of the high speed printer are used in a much wider context than just to make blind individuals able to program. During the training of candidates, materials to be read and studied are routinely formatted and embossed on the computer. It is useful to provide the student with a library of printouts of previously debugged programs for study purposes. In training a deaf-blind programmer, who now successfully occupies a position as systems analyst, training was restricted almost completely to producing such printouts of programs, assembler listings, and other specifications which are not available easily in Brailled form. There is no reason why, with some modification, the high speed printer cannot be made to produce quickly accessible translations of various textual materials. In fact, Mr. John Boyer of Medcomp Corporation, will describe indeed just such a program that uses the high speed printer for embossing (it could use any other display device just as easily) and can produce quickly translation and formatting of technical material into Braille I, 2 and 3.

We have reached a point now at which one can generalize from the experience gained through the use of one method of providing automatically quick and easily accessible translation and embossing in Braille.

Training and placement are as good as they make possible the training of an independent professional. In our modern society, independence in a profession requires the professional to have easy access to the various communications necessary for the performance of his job, such as journals and the literature in his field, memos, job descriptions or position statements. Viewing experience in training and placing blind individuals for the occupation of computer programmer as a prototype, teaches us a number of important lessons.

1. Independent communication of professional materials is the key to placement. The difference in employment opportunities for blind programmers between 1963 and 1967 lies purely in the ease with which reading materials and computer printouts could be made available to the professional blind person then and now.

2. The rapid access to technical material is the key to successful training. While there do exist many facilities to produce Braille or other suitable translations, they cannot be utilized possibly to provide the many specialties of professional work with the necessary background reading materials. However, a reading machine of the type used for work with computers makes it possible to provide blind trainees with adequate study materials.

3. The key to placement in any technical field is a visible demonstration of the independence with which the blind applicant can function in his job. In our experience, the employer ceases to find objection to the employment of blind persons when he has seen the ease with which the blind programmer obtains brailled output from the high speed printer.

If we combine these lessons we can conclude that fast, efficient, inexpensive methods for translating texts into Braille are still the major requirements for job training and placement. Between advances in engineering and data processing skills, it is possible to design systems that will produce such translations easily and without undue expense. Our job now seems to be to go ahead with building such systems.

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BRAILLETRAN: A COMPREHENSIVE BRAILLE TRANSCRIPTION PROGRAM
(with emphasis on technical material)

John J. Boyer

I feel greatly honored to be a member of this Conference. You will already know that I am here to report on the work which we at Medcomp Research Corporation, in cooperation with the University of Cincinnati, have been doing on Braille transcription programs. Only two programs, or rather a system of two interlocking programs called Brailletran, is involved, but this system does practically everything needed for the transcription of textbooks except draw pictures.

About a year ago, Dr. Sterling asked me to develop a Brailler program which would use the embossing method he had described and would also have Grade 2 capabilities. Given this general mandate, I then set about working out the other specifications. First of all, Grade 2 translation would be of little use unless the output were properly formatted and some reader reference aids were included. Then since the program would probably be used a great deal for the transcription of technical material, it should have special features for the handling of such things as tables and mathematical expressions. It should, as a matter of fact, be a complete textbook transcription program. To make it really useful it should be compatable with a large number of computer installations, which meant that no exotic input-output devices should be required. In fact, card images would be by far the best form of input. Moreover, it would be well to develop a simple mnemonic control language. Thus the standard input format for Brailletran would be a series of card images containing the text to be translated along with the necessary control statements. Other forms of input, such as compositors' tape, could be translated into this format off-line on machines having the necessary input devices, a procedure which would probably be more efficient anyway. To ease the job of both the human key-punch operators and of the conversion programs, Brailletran should be highly "intelligent," requiring as little information over and above that contained in the text as possible. Finally Brailletran should be as economical to operate as it could be made, which meant that the functions of translating and embossing would have to be separate.

This last consideration led naturally to the development of two interdependent programs. Brailletran Proper is written for an IBM 7040 and does all translating and formatting. The Brailletran Companion Program is written for an IBM 1401 and handles all input-output operations except those on magnetic tape units. I now wish to discuss the main features of each of these, starting with Brailletran Proper.

This program is designed for use with the standard operating system provided for the 7040 by IBM. The machine on which it is run must have at least 16,000 words of core storage and four tape units.

A salient feature of Brailletran is its mnemonic control language. This consists of 35 control statements, which control translating, formatting, job handling, and so on. Control statements are set off from the text by being enclosed within slashes or diagonal strokes in much the same way as a phrase might be enclosed within parentheses, and each consists of a keyword, which may or may not be followed by modifiers. The following discussion of other features of Brailletran provides numerous examples of control statements.

I turn now to what is probably uppermost in your minds -- the types of translation available. The most important is English Braille Grade 2, which is assumed to be the one desired unless some other mode is requested. It is nearly perfect, except in some cases where the size of the whole-word letter combination exceeds the word-length of the 7040. The control statement /GRADE2/ is provided for returning to this mode after using Grade I translation, which is obtained through the control statement /GRADEI/. In most cases the handling of mathematical expressions is automatic, the change from literary to mathematical translation and back again being made in accordance with the character combinations encountered in the text. For those cases in which it is not, the control statements /MATH/ and /NOMATH/ are provided. The translation itself is in either a simplified version of the Nemeth Code or in Ucode, the system of programming Braille adopted at the University of Cincinnati. The control statements /NEMETH/ and /UCODE/ are used to switch between the two. A special type of Grade I Braille is provided for the transcription of foreign languages. It can be obtained by using the control statement /FOREIGN/, while the statement /ENGLISH/ causes resumption of English Braille Grade 2 translation.

And now let us consider formatting. The main formatting activity is, of course, arranging the output in page form. The control statement /OUTPUT/ is used to specify the size of the paper to be used for embossing, thus providing the information needed for this job. Other format-control statements are used to vary the way in which the output is placed on the pages. For example, the /INDENT/ statement causes a new line to be started and to be indented the specified number of spaces. As another example, take the /TITLE/ statement. This causes the title which follows to be centered on a line, with blank lines before and after, and also to be entered into the table of contents.

Besides translating and formatting, Brailletran provides the Braille reader with several aids and conveniences. First of all, each page is numbered in the lower right-hand corner. In addition, print page numbers may be placed on the output by means of the control statement /PAGE/. These numbers appear both at the points where the page statements were encountered, at the bottoms of the pages, and in the table of contents.

All books are automatically divided into volumes. Each has a certain minimum number of pages, and the division is made when a /TITLE/ statement is encountered or, if this is not possible, when an /INDENT/ statement is recognized. A table of contents is placed at the end of each volume. It contains all titles found in that volume, together with their associated Braille page numbers and, if used, print numbers. A table of contents for the whole book is placed at the end of the last volume.

Brailletran includes quite a number of special-purpose subroutines. As an example, I will take a table transcription facility, activated by the control statement /TABLE/. This makes it possible for the person preparing the input to simply punch the contents of the table, together with indications of column endings, and leave the dirty work of formatting up to the computer. Headings, blank columns, and blank lines are all provided for. Situations for which no special routines are provided may be handled by various simple combinations of control statements. For instance, poetry can be properly formatted with the control statements /MARGIN/ /NEW/ and /SKIP/.

Of no small importance are the aids to proofreading, correction, and editing which have been built into Brailletran. The program is set up to detect errors in the use of its control language and to print out error messages showing what the error was, the card on which it occurred, and what was done about it. A job may be checked for errors without making a Braille translation by means of the /CHECK/ statement. Moreover, the input cards can be printed by using the statement /PRINT/. Corrections can be inserted either by hand or by means of the update facility of the standard IBM operating system.

So much for the abilities of Brailletran Proper. Now let us take a brief look at the Brailletran Companion Program or BRTC.

This program is written for an IBM 1401 with 4,000 positions of core storage, advanced programming features, and attached printer and card reader/punch. If available, one tape unit and a direct connection to an IBM 7040 may also be used.

The main function of BRTC is to emboss Brailletran output. It can also store this output on cards, for embossing on machines not having magnetic tape units. Up to 99 copies of a book can be made without manual intervention.

Input to BRTC can come either directly from the 7040, from tape written by Brailletran, or from cards punched by BRTC itself during a previous run.

Control of BRTC is achieved in the first instance by the settings of sense switches, and in the second by control cards.

Before I wind up my discussion of the actual computer programs, you would undoubtedly like to know something about their speed. Roughly, Brailletran can translate 5,000 words per minute, while BRTC can emboss six pages per minute. I should also like to point out that both programs can process long strings of jobs without reloading.

We have also given considerable attention to the other links in the translation chain, particularly to the preparation of the input. A Brailletran Reference Manual has been prepared which gives detailed instructions for punching various types of material and also describes the operation and use of the programs.

And now that we at Medcomp have our Braille translation system, what of the future? Well, we have a number of ideas, but their realization will depend upon the availability of research funds. We would like to add

Grade 3 and to develop utility programs to translate compositors' and other kinds of typesetting tape into the standard Brailletran input format. What we are really excited about, however, is the possibility of obtaining input from an optical scanner and storing the output on punched paper tape for conversion into Braille by a simple machine resembling a tape recorder.

If any of you would like to look at some Brailletran output, I have a limited number of copies of some supplementary material to pass out. A number of printed listings of the input cards for this material are also available. I hope you have found this speech informative and will now answer any questions you may care to ask. Thank you very much.

SMALL COMPUTERS AND GRADE 2 BRAILLE*

Professor Edward L. Glaser

The work being conducted under the direction of Professor Glaser at Project MAC concerns producing Braille by means of a very small computer, but it is not intended as a production project. However, it is a sub-set of a much larger project concerned with man-machine interaction which involves other modalities than touch.

The system presently being used consists of a small computer, a conventional teletype unit, a high-speed Braille embosser (developed in the Mechanical Engineering Department at M.I.T.), and a data set interface (for transmission and reception of information over the telephone network). Also under construction is a new electrical Braille keyboard intended to drive the embosser; this Braille keyboard is designed so that it looks very much like the Perkins keyboard. Experiments are being conducted with one-handed keyboards where, with a single stroke, any Braille character can be produced with either hand.

The small computer produces approximately 1.8 Braille, that is, less than Grade 2 Braille. There are three problems associated with machine handling of Grade 2 Braille: (a) the dictionary which is a result of a set of symbols used in normal text and an explicit set of Braille symbols; (b) syllabification which is not written into the small computer program, but which can be; (c) those contractions which, when used incorrectly, ocscure meaning (this problem can be solved by using a very large dictionary, and some ad hoc rules based on general analysis of semantic content).

Braille transcription via small computer is accomplished in several ways: (a) somebody who knows no Braille can sit down at a teletype keyboard and type in material which is simultaneously embossed in Braille by the MIT embosser; (b) instead of the keyboard being in the same room with the computer and embosser, it can be operated from anywhere in the United States and fed to the computer-embosser set-up via telephone lines; and (c) the use of the time-sharing system of a large computer, in conjunction with the equipment mentioned in (a) and (b) as well as the telephone line interface, enables a blind person to communicate (send and receive) entirely in Braille, as well as interrogate his files and manipulate programs.

The price of computers is decreasing rapidly; for example, the computer originally considered for this project cost $28,000, but Braille is currently being produced on a computer which costs $18,000. There is a version of the latter computer which, although slower, is quite adequate and costs only $10,000.

The developments in micro-logic point to circuitry (to be used in a $10,000 to $15,000 computer) reduced in size (a cube 3 to 5 inches on an edge) and cost ($1,000 to $2,000).

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* This is a summary of the comments presented by Professor Glaser

ON READING AND READING BRAILLE

A. P. Grunwald

This presentation is going to be disorganized, because I have not yet written the paper. It is therefore cunningly called a preview.

Nevertheless I ask you you to bear with me for a few minutes so that I may have the benefit of a critical discussion of the material I want to talk about.

We have recently conducted a series of experiments with the purpose of better understanding the Braille reading process. The primary objective of this work was to establish criteria for the design of a Braille reading machine; a report on this effort has been published in Science, the October 7, 1966 issue. However, what I would like to discuss with you now concerns certain more general conclusions which perhaps can be derived from our results.

But before we discuss conclusions, let me first very briefly describe what we did: A device was constructed which moves sheets of paper embossed with Braille characters over a platen, either continuously at precisely controlled rates or in accurately timed steps; in the second case, the paper is at rest between the feed movements.

In this fashion the reader was presented with lines of Braille, which were either moved mechanically under his fingertips or scanned by his fingers while the sheet was at rest.

In order to avoid interference with the measurements by factors such as memory or mental manipulation of words we wanted the reader to pronounce the words he read as he read them and to prevent him from anticipating words. Therefore, we used mostly sheets with randomly selected words (rather than with whole sentences); to provide sufficient time for pronunciation, extra blank spaces were left between words.

With this method we obtained accurate and consistent rate measurements - but how is the rate measured correlated to the speed of actual reading? Fortunately for us it turned out that the relationship is simply one to one.

This relationship was established as follows: We asked several Braille readers first to read a page which we had picked from a high school biology test, without vocalization or subvocalization, word for word, as fast as they could. The same readers took then the pronunciation test outlined before. Finally we presented the subjects with meaningless binary dot patterns (such as dot/dot, dot/blank, etc.) and determined the maximum speed at which the subjects were still able to perceive the presence or absence of the dots, spaced at the distances of Braille dots.

The most interesting result of this program seemed to us the fact, that reading, word pronunciation, and dot resolution tests yielded the same number for maximum sweep rate for all subjects with reliable scores. Not only did each subject score alike on all three tests - but to our surprise, different subjects also had the same score. Furthermore, this score is interesting in itself: the maximum sweep rate turned out to be 13.8 cm per second, equivalent to 22 Braille characters per second or (according to a statistical analysis of the texts used) to ∿ 320 words per minute.

I now turn to certain conclusions based on these data which I would like to discuss with you, which concern the reading process in general, rather than specific engineering problems, which had originally motivated the experiments:

As a first conclusion I offer that the identity of sweep scores on the three different tests indicates that pattern recognition in reading is not correlated to comprehension. Strictly speaking, this has been demonstrated only for Braille reading, but it is tempting to see what happens if one generalized the postulate.

I realize that this postulate - even limited to Braille only - seems to fly in the face of every day experience: we all slow down as soon as we become unsure of the meaning of what we are reading - or do we? Could it be that in this case we do not slow down so much, but rather read intermittently? I do not want to clutter this overview with details which lead me to believe that this actually is the case; suffice it to say that the apparent contradiction may perhaps be resolved by this interpretation.

If the postulate holds, it would be significant for several important matters, such as teaching, reading techniques and perhaps even for printing and other subjects. I propose therefore that it would be worthwhile to investigate this matter more extensively.

Another interesting finding is that the maximum recognition and resolution rates are not only alike for one subject but for several persons, in fact for all those in our sample who scored above ∿ 200 words per minute. This looks to me pretty much like a time dependent neurological phenomenon, which might for instance explain the finding of other researchers that reading speed seems hardly correlated to increasing size of Braille characters. At any rate we are presently attempting to illucidate the nature of the apparent constant.

The second conclusion we propose is that Braille reading - done skillfully - is a dynamic process, that is, that the reader perceives patterns in time rather than in space or that he is concerned with rhythm rather than with geometry. Here are my reasons for this postulate: First it seems easier to reconcile a reading rate of 22 characters per second with dynamic concepts rather than with geometry. More important, impressions on the nerve endings of the fingertips must change constantly as dots and fingers move steadily relative to one another. That this relative motion is indeed steady is borne out by the fact that when we mechanized the scan (and had the reader's fingers held steady) no change in reading rate occurred relative to normal reading with deliberate scanning motions. Finally we found that at the sweep rate of 13.8 cm per second the 3.75 mm intercharacter dot distance is just barely resolved, whereas the 2.5 mm distance between dots within a character is not. Thus, if the reader would need to grasp the "real geometry" of the character in order to understand it, he would not only have to infer it from a moving impression, but also from one which is further modified or distorted by apparent fusion of dots within a character at higher reading rates. We doubt that such a complicated translation process is actually involved in Braille reading, but even if it were, the primary impression on the reader must be continually changing, it cannot be a static one in the light of our findings; it must be in this respect systematically different from what is taught about visual reading.

This would seem to call for some re-evaluation for instance in our techniques in teaching Braille. For example to introduce beginners to a peg board or other stationary geometrical pattern to teach him the appearance of Braille characters is probably a detour; worse (at least to my knowledge) no methods have been developed to help him make the transition to "dynamic" reading, but he is left to make this transition by trial and error development on his own; he is not even directed to focus on the problem he faces in this development, instead his attention is originally directed toward static patterns and that is where the matter rests. The result is that few readers develop a smooth sweep and are severely handicapped in their reading speed. The causal relationship is borne out not only by our experience that it is possible to make a fair guess at a subject's reading speed simply by observing how smoothly he sweeps the line. Furthermore, we found that average and poor readers show an immediate increase in reading rate when the sweep is taken over by our test device and thereby made even, in spite of the fact that this results in (at least to them), somewhat unfamiliar sensations.

Perhaps better understanding of how the written material appears to the reader and how he interacts with it could generally be profitable. Is, for instance, the often repeated statement that the eye reads only during "fixes" sufficiently demonstrated and, more important, what does it mean? How do we achieve continuity in this process, that is, how do we avoid overlapping of fixes and/or redundancy of information or breaks in continuity?

In short, it seems to me that we tend to think and teach Braille as if it was to be seen rather than felt - and I am not even sure that I have an adequate understanding of how we manage to read a printed page visually.

COMPUTER TRANSLATION OF GRADE 2 BRAILLE
American Printing House for the Blind
May, 1964 - November, 1966

Robert Haynes

PRODUCTION

In May, 1964 a 709 computer system was installed at the American Printing House for the Blind. Since that time, 182 titles or 427 Braille volumes have been translated by the computer. The majority of titles were literary books. Also, a textbook series and a number of magazine volumes were translated. One reference book, making 25 Braille volumes, was produced. Input for this book consisted of 100,000 punched cards. The result of translation was 85,000 Braille output cards. Accuracy of the system was excellent from the beginning, and progressed to a level where some volumes contained fewer than five errors. Proofreading is still required for perfect copy.

The card-to-plate equipment developed by APH and IBM has been effective in producing Braille plates from which an unlimited number of copies can be embossed.

Careful attention has been given to production costs. Records indicate the present system as installed at APH is efficient from a cost standpoint.

SYSTEM DEVELOPMENTS

Since the original Braille translation program was written for a 704, input and output instructions were rewritten in 709 language. This change increases speed of translation and uses less core storage.

An intermediate table was inserted to serve as an index to the Grade 2 table, permitting the program to operate at an increased speed.

In an effort to reduce the amount of human intervention required, a common word elimination program was added to the system. By making a test translation of a volume omitting occurrences of the 10,000 most frequently used words and translating only the first occurrence of the remaining words, prooflist checking was reduced by about 90%.

In 1964 a rules change covering Braille textbook format was adopted. Among features of the textbook format is a provision for indicating inkprint page numbers. This adoption was for the benefit of blind students attending classes with sighted students, and using the same texts. In order that the computer could translate textbooks, a program was written to replace the format section of the Braille translation program. The textbook program provides for such things as inkprint and Braille pagination, indexes, interlining, and right margin adjustment. The translation of copy into magazine format was also made possible by the textbook program.

A keypunch manual was written before the second year of production began. This manual serves as a reference for keypunch symbols used in preparing input for Braille translation. A supplement to this manual includes symbols for indicating diacritiing inkprint into computer readable data.

FEDERAL GRANT

A grant from the Office of Education has been received to support research in a number of areas including application to a wider range of materials, hyphenation, and efficiency of hardware use. Initial efforts supported by the grant include:

1. The development of a math translation program. This work is being done by Ann and Joseph Schack.
2. A study of space saved by using hyphenation.
3. The development of a Braille translation routine that uses somewhat different principles.

BRAILLE RESEARCH AT GEORGE PEABODY COLLEGE

Professor Richard W. Woodcock

This report briefly describes three Braille research projects at George Peabody College in Nashville, Tennessee. One of these projects is a test development project originally supported by the Cooperative Research Program of the U. S. Office of Education, and essentially completed at Colorado State College. Additional reliability and normative data are now being gathered by the prinicpal investigator at Peabody. The second project is concerned with the problems of teaching Braille reading to young blind children. This project is supported by the U. S. Office of Education and is in its initial phases. The third project to be described involves the development of an electro-mechanical system designed to facilitate transcription and the small-scale reproduction of Braille. This project has been supported by the National Institute of Neurological Deseases and Blindness.

The Colorado Braille Battery

During the fall of 1966, the American Printing House for the Blind published the Colorado Braille Battery (CBB) and has thus made available to the field a series of tests which allow objective measurement of knowledge of the Braille codes.

The CBB was developed at Colorado State College during 1962-64 by Woodcock and Bourgeault under a contract with the Cooperative Research Program of the U.S.O.E. The battery provides a series of tests for measuring mastery of two Braille codes - the Grade 2 Literary Code and the Nemeth Code for mathematical notation. These tests are not tests of reading or mathematics skill as such, but tests of one essential aspect of the ability to read or do number work in Braille, i. e., how well the subject knows the elements of the Braille codes and the rules governing their use. The eleven tests comprising the CBB are indicated in Table I. Seven of these tests measure knowledge of the Grade 2 Literary Code and four measure knowledge of the Nemeth Code.

The Beginning Literary Tests are most appropriate for use at the first grade level of achievement. They may be used also at the early second grade level; however, the tests become too easy for most second graders by the latter part of that grade. The Intermediate Literary Tests are most appropriate for use the second grade level. They are suitable also for use with higher achieveing first graders. The Intermediate level is somewhat easy for third graders, particularly the better students in a typical third grade class. The Advanced Literary Tests are most appropriate for students achieving at the fourth grade level or higher. It is adequate for third grade use, especially with the higher achievers in that grade. The Pretest may be used advantageously to determine the level of a full-length test which a subject should take when prior information regarding the subject's competency in literary Braille is not known to the examiner. The Pretest may also be used as a short-form literary code test for purposes such as group screening to determine which subjects require a more thorough evaluation,

TABLE I

TESTS COMPRISING THE COLORADO BRAILLE BATTERY

Test	Forms	Number of Items	Level of Achievement Measured
Literary Code Tests: (Grade 2 Braille)			
Beginning Level	A,B	82	Grade I and low Grade 2
Letters Subtest		22	
Punctuation Subtest		12	
Word Form Subtest		48	
Intermediate Level	A,B	69	Grade 2 and low Grade 3
Punctuation Subtest		21	
Word Form Subtest		48	
Advanced Level	A,B	48	High Grade 3 and above
Punctuation Subtest		22	
Word Form Subtest		36	
Pretest	A	13	All levels
Nemeth Code Tests:			
Beginning Level	A,B	34	Arithmetic (Grade 4 to 8)
Intermediate Level	A,B	30	Mathematics

or to obtain a quick estimate of an individual subject's knowledge of the literary code. The Pretest was prepared by selecting 13 highly discriminating items spaced throughout the difficulty range of literary test items. The easiest item has an average grade difficulty level of 2.0. Subsequent items increase in average difficulty by increments of approximately three months. There is only one form of the Pretest and it can be administered in approximately five minutes.

The Beginning Nemeth Tests are most effective as a measuring device between grades four and eight. They are rather difficult for subjects below grade four and tend to be too easy for most subjects by the beginning of grade nine. The tests are appropriate for use at any level if the primary interest is in the subject's knowledge of the Nemeth Code as used in the preparation of arithmetic tests and materials. The Intermediate Nemeth Tests are most appropriate for students who have had some advanced work in mathematics using the Nemeth Code. There were few such ubjects available in the standardization sample, thus the norms resulting from this portion of the study are tentative. Furthermore, grade norms for the Intermediate Nemeth Tests are virtually meaningless due to the small change in median performance from grade to grade. Percentile norms for grades nine and ten will be of the most value to users of the Intermediate Nemeth Tests desiring national norms.

All tests of the CBB are designed for group administration and are administered orally. The questions are multiple-choice, five-alternative items. The administration of the tests follow the same pattern for the entire battery. The examiner indicates the desired response and the subjects determine which of the five alternatives is the correct Braille representation of the oral stimulus just presented by the examiner.

The CBB should be quite useful in many Braille research projects. The tests may be used with either children or adults for whom it is desired to obtain a measure of Braille code knowledge. They may also be used with sighted teachers of Braille and Braille transcribers. Since there are two forms for each test, it is possible to get up research designs requiring pretests and posttests.

A technical report describing the development and standardization of the CBB has been prepared. This report may be obtained from either the American Printing House for the Blind or from Woodcock of George Peabody College.

Comparative Study of Braille Reading Instruction

Dr. Randall Harley has a grant from the U. S. Office of Education to study the efficacy of six ways of teaching beginning Braille reading. Harley's study will involve a comparison of three different Braille codes along one dimension, and a comparison of a synthetic (phonic) approach and an analytic (whole-word) approach along the second dimension. The design of Harley's study is illustrated in Figure 1.

The phonemic Braille code being developed for the project is similar

	Grade I Braille	Grade 2 Braille	Phonemic Braille
Synthetic Approach	Grade I - Synthetic	Grade 2 - Synthetic	Phonemic Synthetic
Analytic Approach	Grade I - Analytic	Grade 2 - Analytic	Phonemic-Analytic

Figure I. Design of the Harley study

to the Initial Teaching Alphabet (i.t.a.) being used extensively in research with sighted children. A phonemic alphabet generally contains about 40 characters - one for each phoneme of the English language. Children first learn to read materials written in the phonemic alphabet and later make a transition to materials written in the traditional 26 letter alphabet.

A synthetic approach to teaching reading is one in which children first learn the sound of letters and then learn to synthesize or blend these sounds into words. Lippincott publishes a series of readers based upon this philosophy of reading instruction. This series of readers is to be transcribed into Grade I Braille, Grade 2 Braille and phonemic Braille for the purposes of this study.

In an analytic approach to teaching reading, children typically learn a vocabulary of 75 to 100 sight words before they begin their phonics program. Scott-Foresman publishes a series of readers which will be used in this portion of the study. The Scott-Foresman series is already available in Grade 2 Braille. The series will be transcribed into Grade I Braille and into phonemic Braille for the purposes of this study.

Braille Equipment Project

This report briefly reviews the progress of several interrelated projects underway since 1961. The initial objective of these projects was to develop and evaluate a system of electromechanical devices for facilitating the transcription and small-scale reproduction of Braille materials. Since January of 1964 the focus of the project has been broadened to include activities related to training potential users of the system.

The work with this system was begun by Woodcock in 1961 at Colorado State College. At that time, a pilot model of the system was designed and constructed to demonstrate the feasibility of the concept. This pilot model was comprised of an electrically-operated Braille writer and several input devices for controlling the brailler. These input devices included an electric keyboard with the same configuration of keys as a manual brailler; a keyboard designed for one-hand operation, similar in appearance to small adding machine keyboards; a typewriter keyboard which incorporated electric circuits for translating typing into equivalent Braille cell combinations; and a perforated paper tape reader for automatic reproduction of Braille materials. This pilot model was exhibited at the International Congress on Technology and Blindness, held in New York City, June, 1962.

Since January, 1963, the project has been supported through research grants from the National Institute of Neurological Deseases and Blindness (U. S. Public Health Service). These funds have been used for redesigning and improving the system; evaluating its mechanical and electrical reliability; developing a self-instructional manual for Braille transcribers, using a specially modified teletypewriter; and, conducting a comparative study of three approaches for training Braille transcribers.

Equipment development since 1962 has been focused primarily upon three items - an electric brailler, a perforated paper tape reader, and a specially modified teletypewriter for use by Braille transcribers. Developmental work on the electric brailler originally concentrated upon the concept of an auxiliary power unit attached externally to a standard manual brailler such as a Perkins or a Lavender. This auxiliary unit operated the manual brailler through solenoids and a small motor. Recently Howe Press, manufacturer of the Perkins brailler, has cooperated in building a series of four electric braillers. Howe Press is continuing development of this device and may put an electric Perkins in production if the developmental models perform satisfactorily. The electric brailler has provision for electrical connections allowing operation by automatic paper tape equipment, or special keyboards such as a typewriter keyboard. The estimated cost of an electric brailler in production would be over $100, but probably less than $200.

A significant outcome of this project has been the development of a specially modified Model 33 typewriter for use as a Braille transcribing device. Three major modifications were made by the Teletype Corporation in redesigning the Model 33 teletypewriter as a Braille transcribing device. First, the keyboard has been specially labeled. Second, extensive redesigning of certain internal mechanisms was necessary in order to operate the machine in accordance with the Braille code, rather than the machine code used by Teletype Corporation in its equipment. Third, a special set of printed characters has been designed to represent the meanings associated with each of the 63 Braille cell combinations. This set of printed characters with associated Braille cell combinations and meanings in Grade 2 Braille are shown in Table 2. This set of print characters has been termed a "type-counterpart Braille" by the project staff. This term has been reduced further to the single word "tyco-Braille". The modified teletypewriter is referred to by the project staff as a "Tyco-Brailler".

The development and use of this set of print characters is of special interest to sighted transcribers since it allows material transcribed into Braille to be proofed visually by reading printed characters, rather than reading the embossed Braille. Thus, it is not necessary for a

TABLE 2

COMPARATIVE CHART OF BRAILLE AND TYCO-BRAILLE SYMBOLS

Braille Symbol	Tyco-Braille Symbol	Associated Meanings	Braille Symbol	Tyco-Braille Symbol	Associated Meanings	Braille Symbol	Tyco-Braille Symbol	Associated Meanings
⠁	a	a 1 (one)	⠧	V	v very	⠪	OW	ow
⠃	b	b but 2	⠺	W	w will	⠩	SH	sh shall
⠉	¢	c ¢ can 3	⠭	X	x it	⠌	S/	st still /
⠙	d	d do 4	⠽	y	y you	⠹	TH	th this
⠑	e	e every 5	⠵	Z	z as	⠱	WH	wh which
⠋	f	f from 6	⠜	AR	ar	⠯	&	and
⠛	g	g go 7	⠆	B;	bb be ;	⠴	B=	by was " (closing)
⠓	h	h have 8	⠼	#	ble number sign	⠿	FR	for
⠊	i	i 9	⠒	C:	cc con :	⠦	H?	his ? " (opening)
⠚	j	j just 0 (zero)	⠡	CH	ch child	⠔	IN	in
⠅	k	k knowledge	⠤	C-	com -(hyphen)	⠷	OF	of
⠇	l	l like	⠲	D.	dd dis $. (period)	⠮	TE	the
⠍	m	m more	⠂	E,	ea , (comma)	⠾	WT	with
⠝	n	n not	⠢	EN	en enough	⠘	45	45
⠕	o	o	⠫	ED	ed	⠨	46	46 italic sign . (decimal)
⠏	p	p purple	⠻	ER	er	⠸	.5.	456
⠟	q	q quite	⠖	F!	ff to !	⠐	5	5
⠗	r	r rather	⠶	G()	gg were ( )	⠰	56	56 letter sign
⠎	s	s so	⠣	GH	gh	⠠	6	6 capital sign
⠞	t	t that	⠬	NG	ing	⠄	'	' (apostrophe)
⠥	u	u us	⠳	OU	ou out	⠈	/	′ (accent sign)

Braille transcriber using the Tyco-brailler to learn the Braille cell combinations. This system of print characters provides an exact one-to-one relationship between Braille cells and print characters. Figure 2 illustrates the tyco-Braille printout obtained from the Tyco-brailler.

The Tyco-brailler is available from the Teletype Corporation as Model 33TC7571S. Its present cost is approximately $1,600; however, this price may be reduced somewhat if production lots become large enough so that the machines could be assembled on Teletype's production line rather than in their model shop. The basic output of these machines is a perforated paper tape, which in turn is used by a paper tape reader to operate automatically an electric brailler. These tapes may be used also to operate stereotyping equipment in printing houses for the blind.

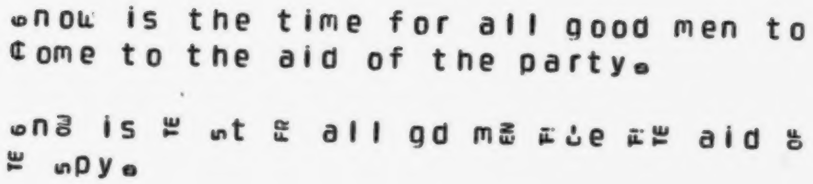
Since June of 1964, extensive efforts have been devoted toward developing a self-instructional manual for the training of Braille transcribers using the Tyco-brailler. The Braille manual by Ashcroft and Henderson, entitled "Programmed Instruction in Braille," was used as a point of departure in developing the tyco-Braille transcriber manual. The purpose of this manual is to provide instruction in Grade 2.0 Braille code and in the operation of the Tyco-brailler for future Braille transcribers.

The present manual has been developed through several pilot runs with college students serving as subjects for the training of Braille transcribers. As these subjects have proceeded through the manual, they have evaluated and criticized each lesson. This feedback was subsequently used in rewriting the manual.

Since October of 1964, a comparative study of three approaches for training Braille transcribers has been underway. The three approaches used in this study are the Library of Congress training program for Braille transcribers, the Ashcroft-Henderson "Programmed Instruction in Braille," and the Tyco-brailler approach. Approximately 20 subjects are being trained under each of the three approaches. Such measures as "hours to complete the training program" and "transcribing accuracy" are to be analyzed.

In conjunction with the development of the brailling equipment described above, a comparative study of three approaches for training Braille transcribers was made. Comparative data were desired regarding the time required to complete the transcriber training programs and the accuracy of transcribing at the end of the program. One group of potential transcribers used the Library of Congress program and manual braillers; a second group used Ashcroft and Henderson's "Programmed Instruction in Braille" and manual braillers; and the third group used the Ashcroft-Henderson program modified for use with the Teletype Braille transcribers. The results of this study are summarized in Table 3.

The final report of this project will appear in a few months as an issue of the Research Bulletin published by the American Foundation for the Blind. This report will include a technical report of the equipment development, a report of the Braille transcriber study, and the modified Ashcroft-Henderson manual for training Teletype Braille transcribers.



now is the time for all good men to
come to the aid of the party.

Figure 2. Samples of Grade 1 and Grade 2 Tyco-braille printout.

Table 3

Braille Transcriber Study -- Summary Data

	Lib. of Cong. Manual	Ash.-Hend. Manual	Ash.-Hend. Teletype
All Subjects			
Median hours	139.5	103	59.5
N	18	19	16
Dropouts	8	8	5
Subjects Completing Program			
N	10	11	11
Hours of training:			
Mean	110.8	87.0	54.5
SD	27.1	18.0	6.0
CBB errors:			
Mean	4.3	5.5	1.9
SD	2.9	6.4	1.4
"Maggie" errors:			
Mean	13.0	25.0	15.7
SD	7.8	27.6	6.3
"Dear Pearl" errors:			
Mean	35.8	48.7(N=10)	23.7
SD	20.5	25.3(N=10)	9.4

THE EFFECTS OF PATTERN COMPLEXITY AND REDUNDANCY ON THE TACTUAL RECOGNITION OF METRIC FIGURES

Emerson Foulke and Joel Warm

In recent years, a number of investigations have been concerned with the appropriateness of information measures to the problem of form perception (Forgus, 1966; Michels and Zusne 1965). One approach, under this strategy, has been to specify exactly the statistical features of populations of forms in terms of information parameters and then to study man's ability to identify stimuli drawn from these populations (Alluisi, 1960; Fitts, et al., 1956).

Two parameters influencing the identification of metric figures are complexity and redundancy. Complexity is specified by the average uncertainty or the information content of a figure and is therefore a function of the size of the population of possible figures from which a given figure is drawn. Several kinds of redundancy are possible, and the effect on performance depends upon the kind of redundancy (Fitts, 1956). In the present study, Fitts' Redundancy I was employed. This is a redundancy produced by placing a constraint upon the way in which figures are sampled from the population to which they belong. (See Stimuli under Method)

A series of studies by Alluisi and his co-workers indicate that the speed and accuracy with which figures are identified is determined, at least in part, by their complexity and redundancy (Alluisi, 1960; Alluisi and Hall, 1965; and Baker & Alluisi, 1962). The position taken by these researchers is that if variables defined in terms of information parameters influence performance on perceptual tasks, the perceptual process mediating such tasks may be one of information reduction.

Although tasks in which information parameters are varied have made use of visual stimuli, the information approach implies central mechanisms of stimulus encoding in the perception of form. Since the appreciation of form or pattern is not limited to the visual channel, crossmodal studies of form perception in which information parameters are varied should provide evidence relative to the hypothesis of a central process. For instance, Baker & Alluisi (1962), using visual metric figures and their auditory analogs, varied information parameters and obtained similar results. In the present investigation, tactual metric figures analogus to the visual metric figures employed by Alluisi and others were employed. This was done in the belief that a comparison of the results of the present experiment with a substantial body of research results obtained with visual metric figures would further elucidate the hypothesis of a central mechanism in form perception.

Further evidence regarding the generality of information processing in the perception of form might be obtained by examining the performance of blind Ss on tasks requiring identification of figures by touch. If form perception is mediated by a process that is independent of modality, the performance of blind Ss on a task requiring figure identification should resemble the performance of a comparable group of sighted Ss. Ewart and Carp (1963) and Worchel (1951) have shown that blind Ss can identify geometric forms by touch as accurately as sighted Ss can by sight. However, the forms used in these studies were of the sort that cannot be described conveniently by information measures. Consequently, such results, though suggestive, do not lend themselves to a comparison of the performance of blind and sighted Ss on a task in which information parameters are varied. In the present study, blind and sighted Ss identify metric figures by touch.

METHOD

Subjects

Twenty-four students, drawn from psychology classes at the University of Louisville, and twenty-four legally blind individuals living in the Louisville metropolitan area, served as Ss in the experiment. Each group contained eleven males and thirteen females. The Ss in the sighted group ranged in age from seventeen to thirty-five years, with a mean age of twenty years. Blind Ss were older, ranging in age from seventeen to sixty-five years, with a mean age of forty-one years. All of the blind Ss had completed at least six school grades, and all of them made regular use of Braille in recreational reading or as a job requirement. All Ss were paid volunteers.

Stimuli

The stimuli in the experiment were punctiform metric figures, to be identified by touch, and analogus to the visual metric figures used by Alluisi and others. Metric figures are relatively simple shapes, resembling histograms, which are generated by random sampling of column height in a symetrical row by column matrix. (See Fig. 1.) The logic underlying their use, and the methods employed in their quantification have been described in detail by Alluisi (1960), Baker and Alluisi (1962) and Fitts, et al. (1956). Figures at four levels of complexity were generated by random sampling of column heights in three by three, four by four, five by five, and six by six matrices. To produce redundant figures at each level of complexity, column heights were drawn for each figure with the constraint that each of the possible column heights must appear once and only once.

Apparatus

Using the specifications generated by the sampling procedures just described, dot patterns were embossed on aluminum, using a specially constructed Braille slate. Vertical and horizontal spacing between adjacent dots, center to center, was .095 of an inch. This value is standard for the Braille code. Patterns were centered on aluminum sheets, approximately two inches on a side, and these were mounted on one-quarter inch masonite blocks to promote ease of handling and durability.

Stimulus patterns were presented for tactual inspection in a partially enclosed box, placed on a table between S and E. The three blocks containing the stimulus patterns involved in any given comparison were fitted into appropriate jigs on the floor of this box. S gained access to the stimuli by putting his preferred hand through a curtained front of the box. S found the

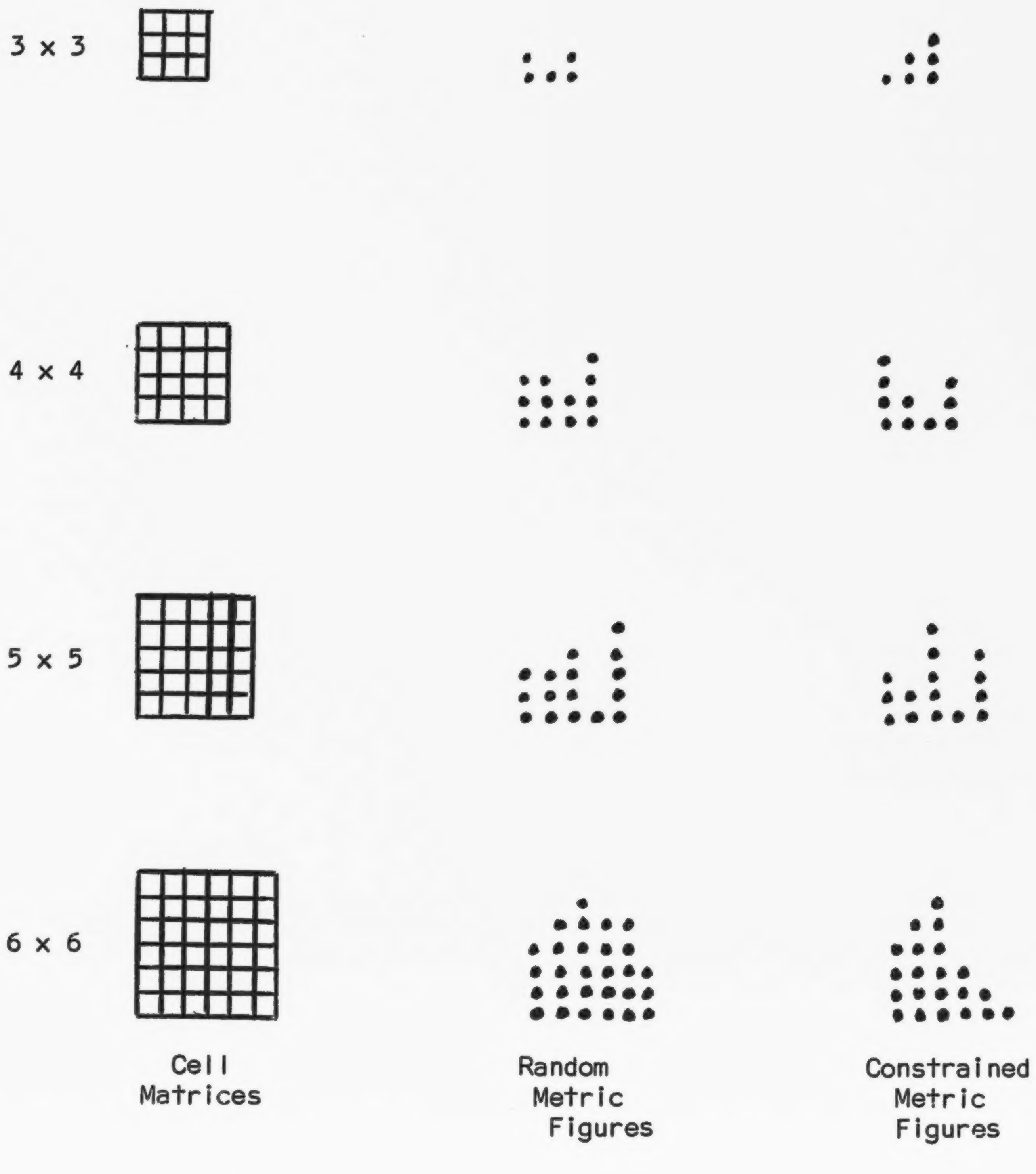

3 x 3
4 x 4
5 x 5
6 x 6
Cell Matrices
Random Metric Figures
Constrained Metric Figures

Fig. 1. Cell Matrices of Different Complexity and Samples of Metric Figures Using Braille Dots

"standard stimulus" by following with his finger a raised runway near the left-hand edge of the box. When his finger made contact with the standard stimulus, a time delay relay, controlled by photo cell circuitry, was energized. When this relay closed at the end of the four second examination period, a buzzer sounding for one half second informed S that the examination period was over and he removed his hand from the standard stimulus. Upon a signal for E, S followed a raised runway near the right-hand side of the box which led to the two "comparison stimuli". Contact with either of these stimuli interrupted a beam of light, and this interruption started a Standard Timer Type S-1 controlled by photo cell circuitry. S's task was to decide which, if either of the two comparison stimuli, was like the standard stimulus. He indicated his choice by operating, with his other hand, a response keyboard consistaing of three momentary switches labeled one, two and neither. S's response stopped the Standard Timer and turned on one of three lights. Thus E, by noting the light that was turned on and by reading the timer, could keep a record of response accuracy and time.

Experimental Design

Thirty-six judgments were required of S in each of the four experimental sessions, half with random figures and half with redundant figures. The order of presentation of random and redundant figures was counterbalanced across Ss. Figures at one level of complexity were presented during an experimental session. In both the blind and sighted group, each S encountered one of the twenty-four possible orders of four levels of complexity as he progressed through the four experimental sessions.

At each level of complexity, there were six random and six redundant figures. During a session, each figure in its group of six figures, served as the standard stimulus three times. On two of these occasions, it was also used as a comparison stimulus, once in Position 1 and once in Position 2. On the remaining occasions, it was not used as a comparison stimulus. The three comparisons in which a given standard stimulus was involved were presented in random order. Since each figure in its group of six figures was presented three times as a standard stimulus, there were eighteen occasions on which a standard stimulus was presented. This order of presentation was random with the restriction that a given standard stimulus could not occur more than twice in a row. The other figures to be compared with the standard stimulus were selected at random from among the five fingers remaining after the standard stimulus had been chosen, with the restriction that no figure could be used as a comparison stimulus more than three times in a row.

Procedure

At the beginning of the first experimental session, E read orally instructions acquainting S with the nature of the task. S was told that both speed and accuracy were important in making his judgements.

At the beginning of each session, Ss were given practice trials with figures at the level of complexity specified for that session. Practice figures generated from the three by three and five by five matrices were random, while practice figures generated from the other two matrices were redundant. Practice figures were not used in the experiment proper. During practice, Ss were given immediate knowledge of results, and practice was continued until a criterion of four consecutive correct responses was met. Following this, the thirty-six experimental trials (eighteen with random figures and eighteen with redundant figures) that made up a session were administered without knowledge of results.

RESULTS

Two measures of performance were computed from the data of each S: (a) the percentage of correct identifications and (b) median response latencies for correct identifications. Mean percentages of correct responses for blind and sighted Ss under all experimental treatments are plotted in Fig. 2.

With the use of three response alternatives per trial, Ss in the present study had to obtain accuracy scores of 59 percent or more in order to demonstrate better than chance performance at the .01 level for any block of 18 trials. Examination of Fig. 2 reveals that on the average, Ss in the present study were able to identify the stimulus patterns with a degree of precision for exceeding chance expectations.

The percentages of correct responses for each S under all conditions of the experiment were transformed into arc sines (Winer, 1962) and the data were then treated by analysis of variance. Statistically significant effects were found between the blind and sighted groups (F = 8.02, df = 1/46, $p < .01$), between complexity levels (F = 32.57, df = 3/138, $p < .01$) between sampling rules (F = 10.70, df = 1/46, $p < .01$). Further, the interactions between groups and complexity (F = 9.02, df = 3/138) groups and sampling rule (F = 7.74, df = 1/46) and complexity and rule (F = 6.49, df = 1/138), were also found to be statistically reliable ($p < .01$ in each case).

In order to understand more clearly the implications of the various interactions, F-ratios were computed for differences between the blind and sighted groups at each complexity level and with figures constructed under each sampling rule (Winer, 1962). Additionally, separate analysis of variance and associated Duncan Multiple Range Tests (Edwards, 1960) were performed on the data of the sighted and blind Ss with respect to differences between complexities and sampling rules. An alpha level of .05 was set for all comparisons. Results are summarized below for each major dimension of the study.

Blind vs. Sighted Ss - Blind Ss were more accurate than sighted Ss in identifying patterns generated from the two lower complexity levels but no differences between these groups were evident with the more complex patterns. Further, the superiority of response accuracy in the blind Ss at the lower complexity levels was more pronounced with random than with constrained figures.

Sampling rule - The overall effects of sampling rule were negligible among the sighted Ss. The blind Ss however were able to identify random figures with a significantly higher degree of accuracy than constrained patterns.

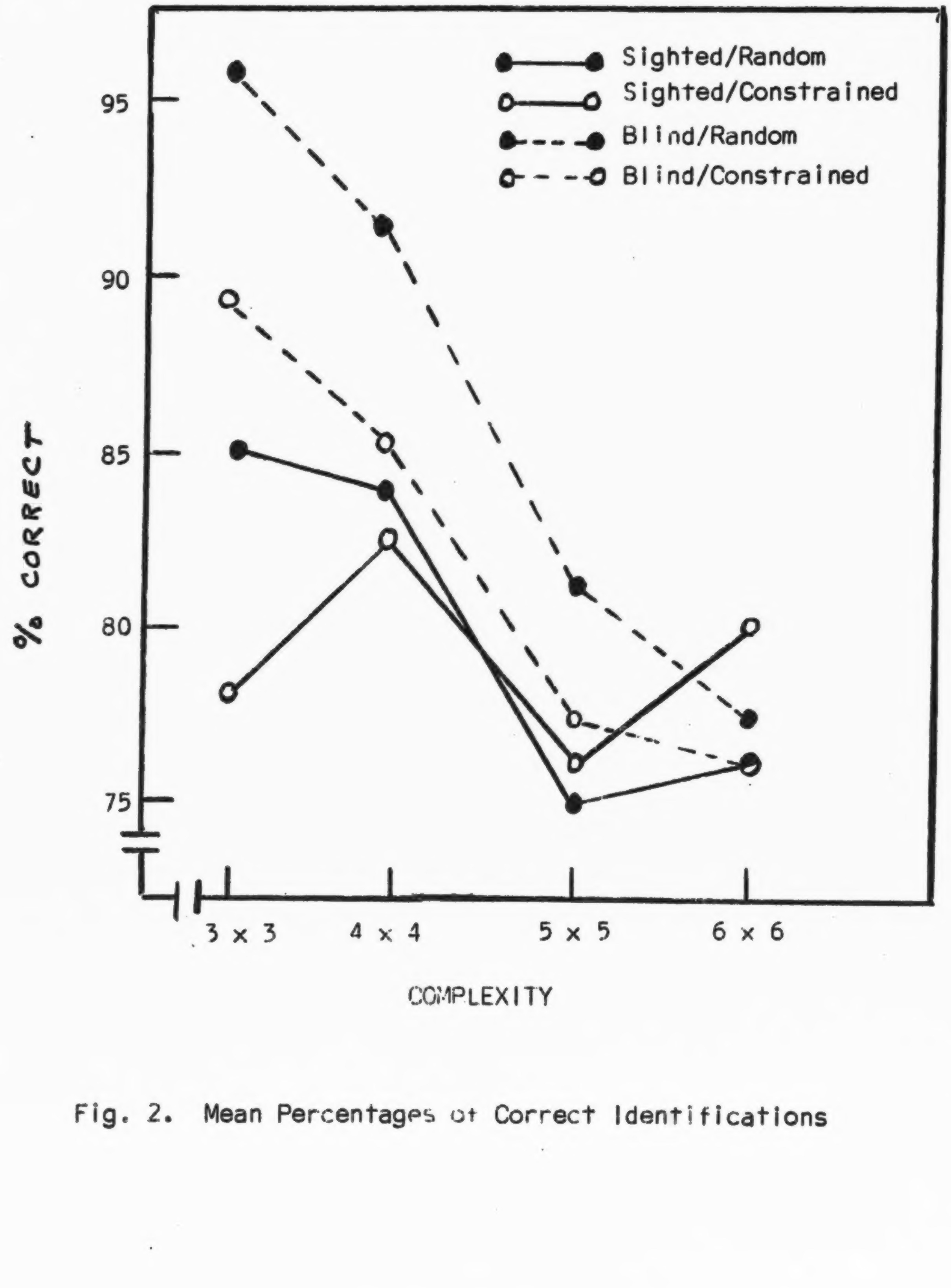


Fig. 2. Mean Percentages of Correct Identifications

Complexity - While overall performance accuracy tended to decline as a function of increments in stimulus complexity, the nature of the differences between complexity levels was closely tied to sampling rule in both blind and sighted Ss. Using random figures, sighted Ss were able to identify patterns generated from the two lowest complexity levels with greater precision than figures generated from either of the two higher levels of complexity. Differences between the two lower complexity levels and between the two higher complexity levels were not statistically significant. Similar effects for complexity were noted for blind Ss with the use of random figures with one exception - in this group, patterns generated from the 3 x 3 matrix were identified more accurately than patterns generated from the 4 x 4 level of complexity. When constrained figures were employed, real differences in response accuracy as a function of stimulus complexity were not noted for the sighted Ss. Among the blind Ss, differences in the precision of identification between complexity levels paralled those obtained with random figures among the sighted Ss.

Means of median response latencies for blind and sighted Ss under all conditions of the experiment are shown in Fig. 3. Analysis of variance of these data indicated that response latencies to correct identifications were significantly shorter for the blind than for the sighted Ss ($F = 30.22$, $df = 1/46$, $p < .01$) and that random figures were identified more rapidly than constrained patterns ($F = 48.85$, $df = 1/46$, $p < .01$). The analysis of variance also showed a significant main effect for complexity ($F = 13.01$, $df = 3/138$, $p < .01$) and it indicated that none of the relevant interactions were statistically reliable. Results of a subsequent Duncan Multiple Range Test revealed that patterns generated from the two lowest complexity levels were identified more rapidly than patterns from either of the two higher levels of complexity ($p < .05$ in each case). Differences in response latency between the two lower complexity levels and between the two higher complexity levels were negligible.

Finally, in an effort to assess quantitatively the degree of similarity between the performance indices used in the present study, a product moment correlation was computed between the mean response time of each S over all experimental treatments and the mean percent of correct response on all experimental conditions. The results indicated that 29% of the variance in response time was associated with difference in response accuracy ($F = -.54$, $df = 46$, $p < .01$).

In the present investigation, an attempt was made to determine if two information parameters which had been shown to be critical variables in the perception of visual form were also applicable to the identification of tactual patterns. The general tendency found here, for performance efficiency to decline with increments in stimulus complexity and the overall trend toward greater performance efficiency with random than with constrained (Redundancy-I) figures accords with findings regarding these variables using visual stimuli. Consequently, the outcome of the present study supports a previous conclusion drawn by Baker and Alluisi (1962), namely, that the information handling approach taps a single form perception process in man. Additionally, the results of the present investigation represent a further contribution to more general efforts aimed at the identification of basic perceptual mechanisms operating across various sensory channels through the study of perceptual analogies in different modalities (cf. Bekesy, 1959; Brown, Condon, C. F., and Hitchcock, 1966; Braumaghim and Brown, 1966; Gaydos, 1956; Hahn, 1960; and Loeb, Behar and Warm, 1966).

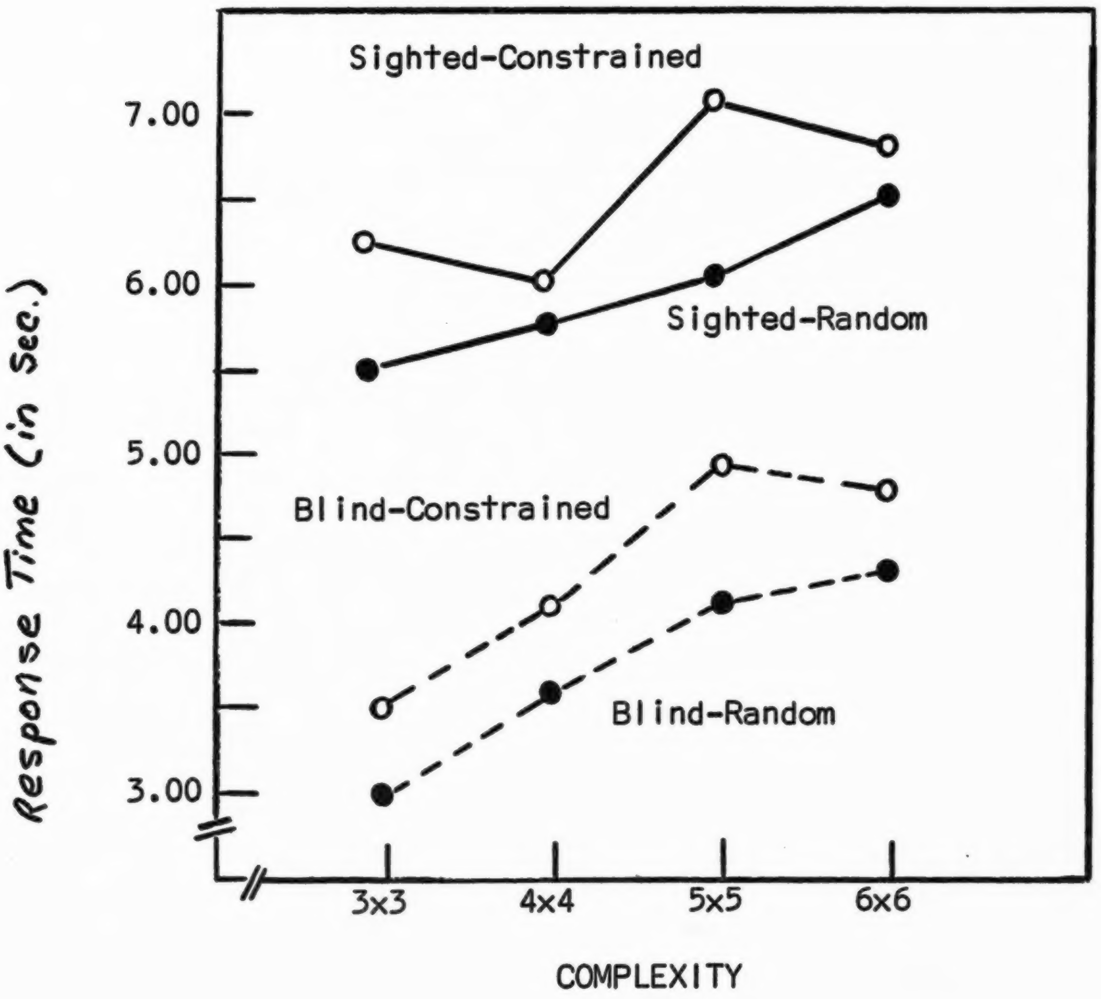


Fig. 3. Means of Median Response Times (in sec.) for Correct Identifications

Comparisons between blind and sighted Ss in the present study revealed two major differences: (a) overall performance efficiency for the blind was superior to that of the sighted and (b) the effects of sampling rule complexity on form identification appeared to differ in blind and sighted individuals when response accuracy was used as a dependent variable but not to differ when performance was indexed by response time to correct identifications. A plausible explanation for the overall difference in performance efficiency between the blind and sighted groups can be based upon differences in prior experience in tasks requiring the recognition of tactual form. All of the blind Ss were skilled Braille readers while this skill was absent among the sighted Ss. In as much as the stimulus patterns used here were analogus to Braille patterns, it seems reasonable to expect a degree of positive transfer among the blind Ss with consequent superiority in performance for this group. It should be noted that such an explanation is consistent with an earlier attempt to account for the superior performance of blind, as compared to sighted, Ss in other tactual-perception tasks on the basis of disparities in initial practice levels (Hunter, 1954).

An important issue in research on form perception has been the question of the equivalence of different response measures (Adams, et al., 1954; Hake and Rodwan, 1966; Michels and Zusne, 1966; Schiff and Isikow, 1966). While previous research has demonstrated a negative correlation between response latency and response accuracy (Austin and Sleight, 1952), response latency has been found to be a more sensitive measure in reflecting the effects of various experimental treatments (Baker and Alluisi, 1962; Fitts, et al., 1956). These relations are illustrated again in the present data by the correlation of -.54 between the dependent measures used here and by the fact that the effects of sampling rule and complexity on the identification of metric forms in sighted Ss was dependent upon the use of a performance criterion based upon response time rather than response accuracy. These findings suggest again that consideration be given to disparities between response measures in attempts to generalize from the results of different investigations involving the perception of form (Adams, et al., 1954; Hake and Rodwan, 1966; Michels and Zusne, 1966).

In addition to implications for basic research, the present data have bearing on applied problems involved in the use of tactual patterns as cues in communication systems. Specifically, it has recently become clear that a need exists for revision of the Braille code to allow for more rapid reading rates and to permit the inclusion of technical symbols used in the various sciences (Rodgers, 1964). One means of achieving such a revision is to expand the standard two by three Braille matrix and thus provide for the generation of an increased number of different patterns. The present data suggest that if symmetrical matrices are used maximum efficiency with respect to both the encoding and decoding of information can be achieved with a four by four matrix size.

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COMPUTER PROGRAMMING AND THE BLIND

Donald Bishop

In April, 1965, the Computer Sciences Laboratory at the University of Southern California began a training course for blind persons in the field of computer programming. The object of this course was to determine the feasibility of training blind persons at U.S.C. in this profession, and to ascertain the need for such a training program.

Three students enrolled in this nine-month program; myself and two other men in their mid-twenties. Instructor for this course was Mr. Lyle Knowles, who was given a leave of absence from the IBM educational center in Los Angeles. Mr. Knowles is presently a doctoral fellow in the Department of Special Education at U.S.C.

The course was designed to develop a good working knowledge of all assembler and compiler languages for the Honeywell 400 and 800 computers. In addition to this, time was spent on the basic concepts of assembler and compiler design, which included writing our own assemblers for the Honeywell 400 computer. Operation and some maintenance of the computers and EAM equipment was also stressed.

Programming problems presented in the course were of a simple mathematical nature for programming in FORTRAN and of a business nature for COBOL. In the last six weeks or so, we were given problems approximating those encountered in job situations. As examples, one student wrote several programs for a church which wanted to automate much of its routine bookkeeping. The other student and I jointly wrote an Information Retrieval System which is currently being used at the Instructional Materials Center, a central depository of information relative to available instructional materials for teaching handicapped children.

In concluding this portion of my talk, I would like to discuss the results of the training program and our findings.

1. After graduation, one student was employed by the State of California in a Civil Service position. The other went on for further training at the Systems Development Corporation and is now employed as a programmer analyst in the Los Angeles area. I am currently a lecturer in COBOL for the Mathematics Department at U.S.C., as well as systems analyst for the Department of Special Education. I will discuss this in more detail later.

2. It was found that great interest exists in California and the Western United States in the training of blind programmers, and that employers are actively interested in hiring blind persons for this type of work.

3. An important factor in the employability of blind programmers is their independence, and no need of special considerations as far as equipment or personnel are concerned. As an example, Braille output from the computer is thought of in many circles to be almost manditory. We have found that,

although convenient, it is not a necessity; in fact, sometimes it can be a deterent to employment when computer time is an important factor. Our findings show that through careful preparation of a program, the blind programmer need use the services of a sighted person for about one minute or so to read diagnostics and check output, and this can be done by anyone, whether they know programming or not. In this situation, the blind programmer is responsible for knowing what he is doing and having his work carefully organized. It should be pointed out that programmers do spend time conferring with one another, and employee interaction is generally present. Such assistance by a sighted person, as I describe, easily falls within this area. When program output is too complex to be checked in this way, the programmer can have his hired reader do such work.

4. We also found that it is as important for the blind programmer to keep up with new information in the field as it is for his sighted counterparts. This usually entails hiring a reader, at one's own expense. Note that such expenses are tax deductable and are well worth their budgetary commitment.

5. We believe that the blind person can compete on an equal basis with the sighted programmer. It should be remembered that one of the basic qualities needed to become a computer programmer is the ability to be creative and adapt to new situations. All the research we have undertaken has shown that no problems, relative to employment, were insolvable, and that most of the solutions to problems were found by the programmers themselves. This conclusion is based on our own experiences, as well as extensive correspondence between ourselves and other programmers throughout the nation.

The training project no longer exists at the University of Southern California. It was discontinued due to the lack of physical facilities and insufficient personnel to warrant the expansion of the program, both necessary if it were to continue.

In my remaining time, I would like to speak about our current work at U.S.C. on a Braille translation system.

Partly as a result of our training project (of which I spoke earlier), Honeywell Corporation became interested in the construction of a printer connected on-line to a computer which would produce useable Braille, and a year ago they announced the development of such a device. It is a modified version of the Model 222 printer used with the Honeywell Series 200 computers. This printer produces Braille on heavy paper suitable for permanent usage. The Braille produced is comparable in quality to that produced by conventional means, and the machine is capable of printing at a speed of 250 to 300 Braille lines per minute on continuous form paper.

The Computer Sciences Laboratory at U.S.C. currently has the only unit of this type in existence. Now that we have the equipment to produce Braille, our major job is to develop a translation system into Grade 2 Braille for the Honeywell H-200 computer. In October (1966), the University received a planning grant from the Department of Health, Education and Welfare to determine needs and system specifications for such a translation system with our computer. I should point out here that, although systems do exist for translating Braille by IBM computers at the American Printing House for the Blind, and here at M.I.T., the computer languages are different for these machines and each machine has features which the others do not.

At this time, we cannot set a completion date for our translation system, because our initial planning grant has just gone into effect.

We feel our system of producing Braille does have great value, especially in the area of producing periodicals or other information which, although of importance at the time of request, might not be of long lasting value. The advantages of on-line printing of Braille, over production of embossing plates for this situation, seem obvious. Thus, it is not our intent to duplicate the work being done by printing houses, but to supplement it by doing that type of Braille production which they may find to be impractical.

In closing, I would like to make it clear that the printer of which I speak is designed to produce Braille of textbook quality. This should not be confused with Braille output from computers, which is used by blind programmers in their own programming work. This printer normally produces ink-print output, and modification to produce Braille takes from five to ten minutes, an involvement of far too much time to warrant conversion for short periods of time, as would be required by the blind programmer for his work. Also, the conversion process must be reversed at the end of the Braille run to resume the normal printing mode, and this involves another three minutes or so.

For detailed information on the Honeywell Model 222 Braille printer, contact the Honeywell EDP directly at their offices in Wellesley Hills, Massachusetts.

COMPUTER PRODUCTION OF BRAILLE AT RNIB

Clive Windebank

I would like to extend the greetings of the Royal National Institute for the Blind to you all here, and to thank John for inviting me to attend and participate in the Conference.

For some time, consideration has been given to the concepts of automatic Braille transcription in England, and we at RNIB toyed with the idea of hiring time on an outside computer, but this was argued out and never completed. Meanwhile, the problem of getting Braille transcribers worsened, and finally last spring IBM agreed to make available to us their 1130 machine, if we considered that this would be suitable for automatic Braille transcription.

Now, this being the case, I was recruited last July to make a hastey study of Braille with the English and the Americans; about a month ago I arrived in Louisville to make a close study of the program at the American Printing House for the Blind. For the next month, I will be here at M.I.T. and in New York making further studies of future developments and hopeful developments in the use of compositors' tapes, math programs, and so on.

We intend to make our English program as compatible as possible with the American system; inputs and outputs will be the same, although the serograph we will be using will be creating solid dots. I hope as far as possible to use the same concepts, but they will have to be modified to some extent because the 1130 is a small machine. It is a 16-bit word length machine, 8K, and I have 500,000 words of disc. But, by too much use of disc, it turns out it will be prohibitive as far as time goes, so I've got a lot of thinking to do along those lines; anyone who can give me a bit of advice, I'll be very grateful for it.

Our aim is to eventually produce 30,000 pages of Braille per year by automatic transcription, and I think from my preliminary estimate that we will be able to manage this. I'm hoping that, God willing, in about 18 month's time we in England too will have a viable automatic Braille transcription system.

COMPUTER CONVERSION OF COMPOSITORS TAPES TO GRADE 2 BRAILLE

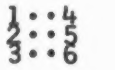
Ann and Joseph Schack

I. INTRODUCTION

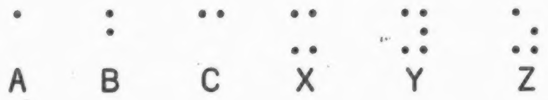
The program described in this report represents the most recent step in the automation of Braille production - the use of compositors tapes as input to a computer program which produces Grade 2 Braille. Underlying this current development (and earlier efforts) is the desire to minimize the amount of skilled manual intervention necessary to produce Braille, and to make more material quickly available to the blind reader.

A. Grade 2 Braille

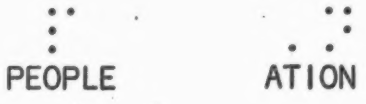
The Braille system of raised dot 'printing' which enables the blind person to 'read' using his sense of touch was first developed by Louis Braille in the 19th century. Although there have been other systems designed for the same purpose, the Braille system has been generally accepted as a world-wide standard. Each Braille character occupies a fixed space, called a cell, in which dots may be placed in any of six positions. These dots are arranged and numbered as illustrated below:



A portion of the Braille alphabet is shown below to illustrate that there is no relation between the dot configuration and the shape of an ink-print character.

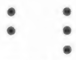


Originally, the Braille code set included only characters for each letter of the alphabet, numbers and punctuation marks. Books were transcribed letter for letter. In the years since its introduction, many additions and changes have been made to the system, each with a view to simplifying the blind reader's task. Today, the letter-for-letter system, called Grade I Braille, is seldom used. Most books are published in Grade 2 Braille - a highly contracted system of representation which utilizes all of the 63 possible dot combinations, many of which have multiple meanings. In the present system (English Braille, American Edition, 1959) there are 189 whole words and letter combinations which may be represented in contracted form. For example, the word PEOPLE is represented by a single code; the syllable ATION by a double code:



Certain words are always abbreviated: BRAILLE is always written BRL; BLIND; BL.

BRAILLE


BLIND

While the shorthand nature of this system facilitates the reading process, it also makes the transcription task extremely difficult.

The transcription difficulties can best be illustrated by examining a few of the rules governing the use of these contraction codes. A contraction may *only* be used to represent a given letter combination, such as THE, SOME, etc. However, it may not *always* be used. There are restrictions based on the position in which these letters occur within a word, the pronunciation of the word, and, in some cases, the meaning of the word or phrase. (In the illustrations which follow, those letter combinations which may be contracted are capitalized.)

One of the simpler rules, because the restriction is based on position alone, is the following:

> The contraction COM may only be used at the beginning of a word..., but it need not be a syllable. It must never be used in contact with a hyphen, dash, or apostrophe.
>
> Ex: COMe   BEcome   home-comING

This is one of the few completely unequivocal rules.

A more typical, and more complex, rule is the following:

> The contractions for BE, CON, and DIS may be used only as *syllables* at the beginning of a word.
>
> Ex: CONcept   cone   DISturb   disc   BErate   bell

Additional difficulties are imposed by rules which are based on meaning:

> One-cell whole word contractions (CAN, FROM, YOU, etc.) when separated by a space from other letters or contractions will be read as a word. They may be used when followed by the apostrophe in *familiar* combinations. However, they should not be used in rare or colloquial forms.
>
> Ex: YOU'll   yOU'n

Even more complex is the following rule which determines the translation of a group of words:

> The word signs A, AND, FOR, OF, THE, and WITH should follow one another without a space *if there is no natural*

pause.

Ex: He walked WITH AND talked WITHTHE boy.

Then, some rules which appear relatively straightforward may be contradicted by other rules based on meaning. For example,

> Final letter contraction (FUL, LESS, etc.) should be used in the middle or at the end of the word. They should never begin a word.
>
> Ex: careFUL fulfill

However, even though the FUL combination occurs in the middle of the word - UNFULFILLED - its use is prohibited by the following rule:

> A contraction must not be used where the usual Braille form of the base word would be altered by the addition of a prefix or suffix.

And, finally, there is the blanket restriction which contributes most heavily to the transcription problems:

> Contractions forming parts of words should not be used where they would obscure the recognition or pronunciation of a word.

In addition to these rules governing translation, there are rigid format specifications about the number of characters per line, the number of lines per page, centering of chapter titles, and proper identification of capitalized and italicized passages. An example of the latter follows:

> If more than three consecutive words are italicized, the first word is preceded by the double italic sign, and the last word by the single italic sign.....In italicized passages comprising more than one paragraph, the double italic sign should be repeated at the beginning of each paragraph, and the final single italic sign should precede only the last word of the last paragraph.

These rules are quoted here to illustrate the difficulties facing the transcriber of Braille. It has been estimated that two years are required to train a skilled transcriber - that is, someone engaged full-time in the production of the metal plates used to produce multiple copies of Braille books. After this period, the skilled Braillist can produce about 30 correct pages a day, or about 12 words a minute. The difficulty of hiring and training transcribers led to the development of a computer program to handle the translation problems.

B. Braille Translation Program

In 1961, a Braille Translation system was written for the IBM 704. Work on this project was guided by the following aims:

1. To limit the manual work to those operations requiring little specialized training.

2. To minimize the calendar time required to publish a Braille volume.

3. To simplify the detection and correction of errors.

The program has been used at the American Printing House for the Blind to translate more than 155 titles in the past two years. Keypunched input to the program is produced by operators who do not know Braille. The test is copied letter for letter, and additional codes are inserted to indicate chapter titles, paragraphs, tables, and other special format conditions.

Translation is accomplished on a word for word basis, and the appropriate translation is determined by a dictionary search and a sub-program which tests the legality of the use of a given contraction. In addition to applying the rules governing the use of contractions, the program produces pages of proper size, numbers the pages, centers chapter titles, and produces properly indented paragraphs and poetry. It also puts out composition signs (capital signs, italic signs, etc.) as required by the Braille rules.

With the exception of pagination and page numbering (which is determined by the program) other format conditions and use of composition signs must be indicated by special codes provided by the keypunch operator. For example, the operator determines the length of an italicized passage and punches the appropriate codes to indicate the beginning and end of the passage. Thus, while the keypunching task is far simpler than that of Braille transcribing, it is not just a copying job, and does require some training.

The program written for and used by the American Printing House for the Blind has, in the main, accomplished it purpose. However, the manual preparation of input remains the most time-consuming and costly part of the transcription process.

As more and more compositors adopted automated techniques, using paper tape driven typesetting equipment, it became apparent that the text with some of the formatting information existed in a machine readable form. The balance of this report describes a pioneering program which demonstrates the use of the six-channel Teletypesetter paper tape as input to a Braille Translation program.

II. SYSTEM DESCRIPTION

Figure A illustrates the machine operations performed in the feasibility demonstrations of the Teletypesetter-tape-to-Braille translation system. It should be pointed out that this does not necessarily represent a description of an operating production system. The conversion of the teletypesetter tape to punched card form, necessitated by the input restrictions of the 7094 CTSS, would not be required for a computer with tape-reading equipment. Similarly, the conversion step required to produce paper tape off-line might also be eliminated.

This system was designed to demonstrate that this form of compositors tape can be converted to quality Grade 2 Braille, using standard, generally available equipment. The demonstration thus indicates that this conversion is not only theoretically, but also practically feasible. There are other computers, large enough to perform the translation and smaller than the IBM 7094, which have paper tape input/output devices. Adaptation of the demonstration program to another system does not represent a formidable task.

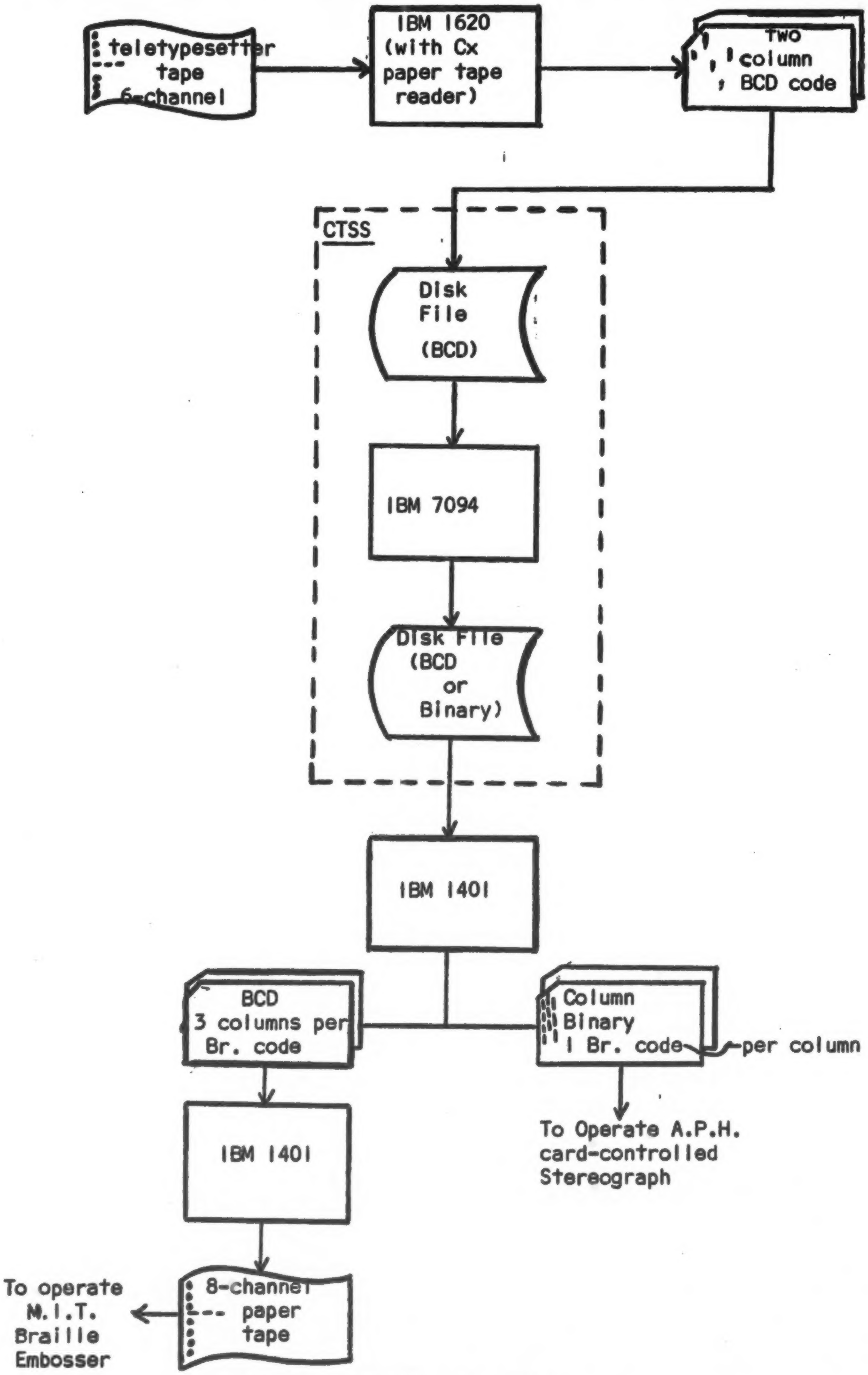

teletypesetter tape 6-channel
IBM 1620 (with Cx paper tape reader)
two column BCD code
CTSS
Disk File (BCD)
IBM 7094
Disk File (BCD or Binary)
IBM 1401
BCD 3 columns per Br. code
Column Binary 1 Br. code per column
IBM 1401
To Operate A.P.H. card-controlled Stereograph
8-channel paper tape
To operate M.I.T. Braille Embosser

Figure A. System Flow Chart

III. PROGRAMMING APPROACH

A. General Description

The programming approach used to produce the translation system described in this report is based on DOTSYS, a system developed by R. Strom, R. Walton, and S. Franklin, and described in the 1965 Final Report of the Sensory Aids Evaluation and Development Center (1). In general, this system permits a series of independent programs to be linked together in whatever configuration necessary to produce the desired output. In this case, each separate program performs a specific code conversion which represents a portion of the translation from a particular input code to some representation of Braille.

In this report, and in the description of DOTSYS, these separate programs are called 'boxes'. However, another name for this kind of program is 'co-routine', although the version used here is simpler and less general. As far as we know, this technique was first used in the scanning sections of ALGOL compilers.

B. Definition of a 'Box'

A box is an independent program which converts information from one coding scheme to another. Information is supplied to a box one character at a time, and the converted results are put out one character at a time. Depending upon the nature of the conversion, any box may collect a number of input characters before producing any output.

Each box has an input and output 'terminal' designed to permit the linking of a set of boxes in any desired pattern. Terminals are simply instructions within each box which are modified by the linking program at the time of loading. For example, the input terminal instruction of box X is modified by the linking program (called HOOK) so that it will receive as input the output from box Y. The output terminal for a given box always calls its own box for input. (This will be explained in further detail in the section describing information flow.)

Each box also has a reset subroutine which is executed by the linking program when the boxes are loaded.

C. Information Flow

Information in the system is acquired by calling a box for output. If the box has any output, it places one character in a specified place (common to all boxes) and returns control to the calling box. If it does not have any output, it 'remembers' who called it and requests input from a preceding box. When it has acquired sufficient input it performs the appropriate conversion and begins to output. Because each box functions independently, there is no correspondence between the number of characters collected by box A and box B. For example, the BRAILL box collects a stream of characters terminated by a space, while the TELCON box may collect as many of 120 characters before producing any output. This flow is schematically represented in Figure B.

D. Advantages

The 'box' approach offers a flexible and general way of handling a complex translation problem. Among the many advantages are the following:

1. Flexibility: A new box can be introduced easily without having more than minor side effects on the balance of the system. This means that the system can easily accommodate new input media, and produce output for new embossing equipment as new techniques develop.

2. Ease of segmentation: When the size of computer storage is too small to contain the entire system, it is easy to divide the system into groups of boxes. Intermediate output, produced by one set of boxes, would become input to the next group - the size of each group, of course, determined by the size of the computer.

3. Dividing the work: When several programmers are working on the same project, the separation of the task into boxes provides natural breakpoints and facilitates communication.

4. Testing: Because each box is an independent unit, designing test input and debugging is relatively simple.

E. Universal Code

There are two boxes which are central to the translation process and which would be included in most configurations: BRAILL and UNICON. The importance of the BRAILL box - which converts BCD input to Grade 2 Braille - is obvious. However, understanding the role of UNICON depends on an explanation of a new coding system, called UNIVERSAL, designed by the authors of DOTSYS especially for purposes of Braille Translation.

The UNIVERSAL code is a nine-bit code designed to serve as an internal link between a variety of input codes and the Hollerith code expected by the Braille Translation box. Although not all of these are currently in use, the nine-bit scheme permits the unique representation of 528 different characters. The decision to use nine bits was based in part on machine considerations, but the choice of an expanded character set is problem determined. Because of this larger set, a single code may be used to represent characters or format conditions which, if keypunched, would require multiple codes. For example, a single UNIVERSAL code stands for A (capital A) while the keypunched representation requires two codes. Similarly, the keypunched format code $PAR_ which indicates the beginning of a paragraph can be expressed in a single UNIVERSAL code.

This nine-bit code is converted to Hollerith by UNICON, a box which is pivotal in the translation system. Because this box does much of the

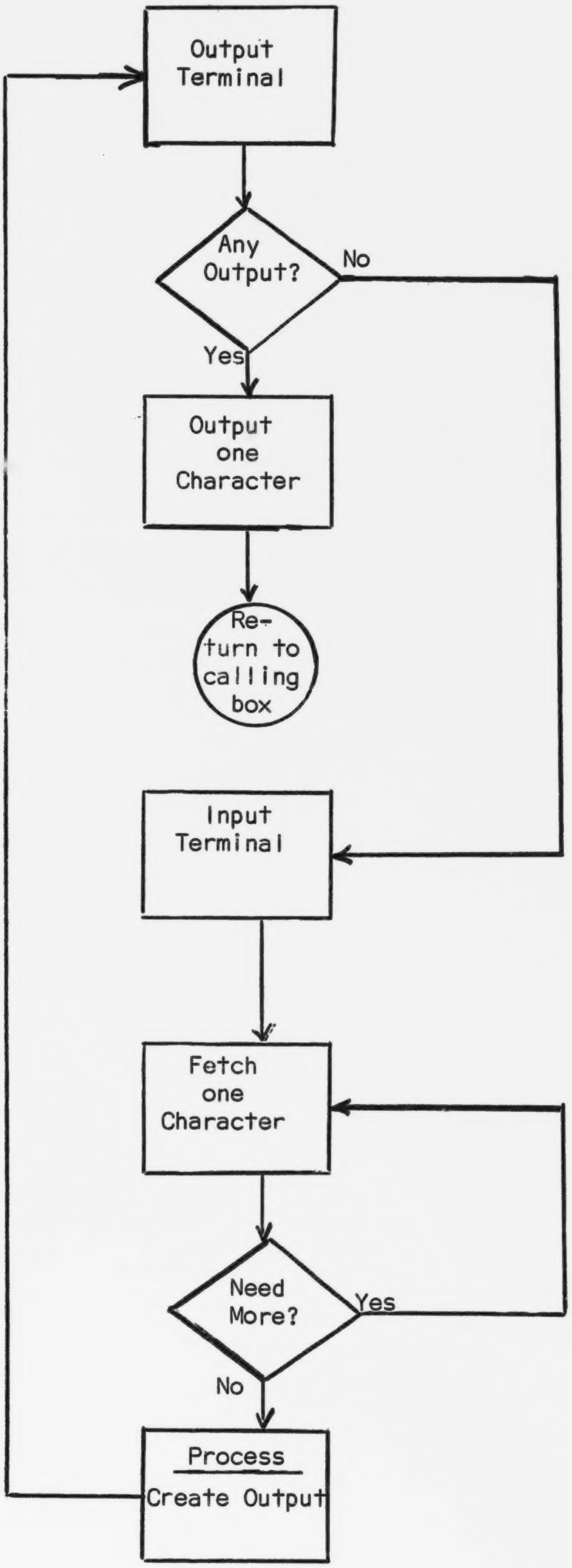

Output Terminal
Any Output?
No
Yes
Output one Character
Return to calling box
Input Terminal
Fetch one Character
Need More?
Yes
No
Process
Create Output

Figure B. Anatomy of a Box

analysis necessary to supply the composition signs and format codes required for Braille, the conversion of compositors tapes is simplified. That is, the writer of a box to convert typesetter code to UNIVERSAL must analyse the codes and punching conventions to produce proper UNIVERSAL code, but need not be concerned with the special input requirements of the Braille Translation box.

F. Typical Configurations

In order to create a particular configuration, the names of the boxes, in proper sequence, are furnished to the linking program - HOOK. The boxes, and HOOK, are loaded together (in any order) and control is transferred to HOOK. HOOK resets all boxes which have a reset entry and links them appropriately. HOOK then transfers control to the proper box and is never heard from again.

A typical configuration was demonstrated at M. I. T. on August 18, 1966. Six boxes were linked to form the system. Input was a Teletypesetter tape produced by United Press International as part of its normal service to newspapers. The output was a card file (later converted to paper tape) which was formatted to drive the M. I. T. Braille embosser. The boxes were: INBOX1, TELCON1, UNICON, BRAILL, FORMAT1, OUTBOX1.

A second configuration, demonstrated on November 18, 1966, used as input a Teletypesetter tape produced by the Poole Clarinda Company of Chicago. That tape contained a portion of a book which had been typeset by the company. Output from this configuration was formatted to drive the card-controlled stereograph machine at the American Printing House for the Blind. For this, the six boxes used were: INBOX2, TELCON2, UNICON, BRAILL, FORMAT2, OUTBOX2.

In the course of testing the system, and as adjuncts to the main demonstrations, several other configurations have been used. One such arrangement (TYPEIN, BRAILL, DOTPR) takes input typed on the 1050 console, translates it to Braille, and produces a printed representation of the Braille on the console. Another, (INBOX, TELCON, UNICON, UNITYP) converts Teletypesetter input to BCD and types the resultant text on the console. This output is what would have been produced by a keypunch operator copying the printed text. The ease of producing these and other configurations is not only important in testing the system, but also provides a dramatic demonstration of the function of individual boxes and the flexibility of the system.

IV. TRANSLATION BOXES AND UTILITY ROUTINES

A. INBOX

The function of this box is to interface with the Input/Output system of CTSS and to read an input file from the disk.

Input

For the demonstration programs, input to this box was a BCD file representing the Teletypesetter codes - each code being represented by two BCD characters. This format was produced by the 1620 program which read the TTS tape and produced punched card output.

Output

Output from this box is a stream of six-bit TTS codes. A listing of these codes appears in the Appendix.

Nature of conversion

INBOX converts the two-column BCD codes to the binary image of the TTS tape codes. It was decided to perform this conversion in INBOX in order to insure the flexibility of the system. The present TELCON boxes expect as input the six-bit TTS tape image and are, therefore, independent of the hardware required to read that tape.

Should the system be adapted for a computer with different Input/Output equipment, TELCON would be unchanged. If an image tape reader is available, a new INBOX would be written to perform file housekeeping, but no conversion.

Flow

INBOX reads a file from the disk, performs the conversion described above, and puts out six-bit codes, one at a time, to TELCON.

B. TELCON

This box converts Teletypesetter code to UNIVERSAL - the code which serves as an internal link to the Braille Translation box. One version of the box, TELCON1, was demonstrated at M. I. T. on August 18, 1966, using tapes of news releases. An expanded version, TELCON2, was demonstrated on November 18 using tapes which represented a portion of a book of political essays.

The choice of Teletypesetter tape as input for these demonstration programs was an arbitrary one. There are many other automated typesetting systems which utilize paper tape input. However, since many of the conversion problems are common to all these systems, this box may serve as a model for boxes to convert other forms of compositors tapes.

Input

The six-bit Teletypesetter code, designed to control automatic typesetting equipment, is input to this box. The tape may contain line-justifying spaces and hyphens, or may be an unjustified tape used as input to a typesetting program. Either form contains all the text material and formatting information required to produce correct Braille. The programs described in this report were written to convert unjustified tape. However, before additional work is done in this area, some investigation of practices in the printing industry is necessary. If the punching conventions for unjustified tapes vary widely among printers, it may be more efficient to write future boxes to convert justified tapes. In any event, the conversion principles described here will be applicable to future developments.

The six-bit structure of the Teletypesetter tape allows for the representation of 64 different characters. Within this set, there are codes for the letters of the alphabet, numbers, punctuation marks, fractions, ligatures, spaces of various size, and several codes which control the operation of the type-casting equipment. A six-bit code may select one of two different type faces, depending on whether it is preceded by a SHIFT or UNSHIFT code. (This is directly analogous to the function of the shift key on a typewriter.) Another set of shift codes (UPPER and LOWER RAIL) is used to select type from a second font. And, on some line casting equipment, a third shift code can be used to set type from an Auxiliary font. Some analysis of printing practices was required to determine how these codes should be interpreted for purposes of translation into Braille. The TELCON programs demonstrated interpret the UPPER RAIL code as a 'Start Italics' indicator. Since the Auxiliary font was used, in the book tape only, to print reference numbers, that shift code was used to supply the reference note indicators required in Braille.

The Appendix includes a chart of the Teletypesetter codes. In some cases, three characters are shown for one paper tape code, indicating that there are optional characters. Some type casting machines may have fractions; other, ligatures. Reflecting the difference between the two tapes used, TELCON1 converts the upper shift of these codes into fractions; TELCON2, into ligatures. It is a simple matter to incorporate this choice into a single program.

Nature of conversion

For convenience, the conversion performed by TELCON may be described under four different headings:

1. One (TTS) to one (UNIVERSAL)
2. One to many
3. Many to one
4. One (or more) to none

This division is for descriptive purposes only. The programming approach, outlined in the last part of this chapter, is a unified one.

1. Most TTS codes have a single counterpart in the UNIVERSAL code structure, and conversion of these requires a simple substitution of the six-bit input code for the nine-bit output code. Included in this group of codes are the letters of the alphabet, numbers and punctuation symbols.

2. Certain TTS codes must be converted to multiple UNIVERSAL codes. This set includes fractions and ligatures (ff, ffl, ffi, etc.).

3. The 'many-to-one' conversion is usually required to produce format codes, and there may be several different groups of TTS codes which will be converted to the same UNIVERSAL codes. The most obvious example is the 'Start Paragraph' code. In inkprint, there are many different ways to indicate the beginning of a paragraph. There may be

a certain number of
special space codes pre-
ceding the first line of
copy,

or,

A series of indented
lines leaving room
for a capital letter
from a special font,

or,

a single line beginning
at the left margin,
followed by a series
of lines, each indent-
ed a certain amount.

In order to produce these (and other) arrangements, there are various sets of codes punched in the paper tape. In the unjustified tapes used for the demonstration programs, the different paragraph formats were represented by special codes originally designed as input to a typesetting program. In all cases, these are preceded by one of several line-ending codes. When one of these line-ending codes is encountered, the program scans for one of the special codes groups (all of which begin with a $) and puts out the proper UNIVERSAL code. A program to convert the justified tape would involve a longer scan, analysing the number and arrangement of space codes, but the conversion process is essentially the same.

4. This group of TTS codes includes several different types. The SHIFT and UNSHIFT codes are not converted directly to any UNIVERSAL code, but are used to influence the table search so that the appropriate code - upper or lower case - is selected. In the justified tape there are a number of codes which would be ignored in the conversion process. These include the line-ending codes, hyphens, and special space codes which are required to produce an even right margin.

Output

Output from this box is the UNIVERSAL code described in Section III and listed in detail in the Appendix.

Flow

If all the conversion performed by TELCON were of the one-to-one variety, the flow would be very simple. However, the other types of conversion require that a variable number of characters be scanned before the proper UNIVERSAL code can be selected. At present, the longest scan is required to determine whether a line is to be centered. The typesetting equipment requires a code at the end of a centered line which causes it to shift the whole line after it has been set. For purposes of Braille translation, there must be an indicator also at the beginning of a centered line. For this reason, TELCON 'saves up' more than enough codes for one line before producing any output. (The present program stores up to 120 characters.) The program begins to output either when a line-ending code is encountered, or when the 'saved' list has been filled. If the line ends with a Quad Center, the box outputs a 'Start Heading' code (147), then the saved line, followed by an 'End Heading' code (150).

A shorter, but more complicated scan is required to recognize the start of a paragraph. Following any Quad code, TELCON scans for one of the special code groups which vary in length depending on the format of the paragraph.

Table

Central to the conversion process is a table of 64 entries, one for each of the TTS codes. The code itself is used to locate the appropriate entry which contains the following information:

(xxx)(index-x)(XXX)(index-X)

where (xxx) is the UNIVERSAL equivalent of the lower shift TTS code, and (XXX) the code for the upper shift. The index associated with each code locates the subroutine which performs the conversion. The one-to-one conversion is accomplished by a very simple routine which handles the bulk of the translation. Routines which convert one-to-many, or which must scan several characters, are, of course, longer and more complex. This table structure allows for very simple program modification and expansion.

It is important to note here that TELCON does not correct or edit the input tape, but reproduces text material as it exists. One major printer has indicated that, in the very near future, their compositors tapes will be complete and error-free. This is made possible by the increasing use of computers in inkprint production. If, however, revisions in the text are necessary for purposes of Braille translation (references to graphic material, etc.) these would have to be handled by an additional box. This problem is discussed in greater detail in the section describing the UNICON box.

C. UNICON

UNICON converts UNIVERSAL code to Hollerith (or BCD). The analysis performed by this box simplifies the writing of boxes to convert various forms of compositors tapes. The form of the output produced insures the flexibility of the system. The Braille Translation box can accept either output from UNICON, or manually produced input.

Input

Input to this box is the nine-bit UNIVERSAL code described in Section III and listed in detail in the Appendix.

Output

The BCD codes output by UNICON are exactly those which would be punched by an operator following the instructions currently used to prepare input for the 709 production program in use at the American Printing House for the Blind. These include not only the letters and numbers of the text, but also special codes to indicate capitalization, italics, paragraphing, centered headings, etc. A listing of these codes and some of the pertinent instructions is shown in the Appendix.

Those few codes which depend on content analysis cannot be supplied by the present program. For example, without editorial comment, there is no way to recognize peotry, or foreign language passages. However, the flexibility of this translation system is such that new boxes can be added at any point in the system. When the system is refined for production use, it is probable that an editing box will be needed, at least for certain kinds of material. The output from UNICON would serve as the basis for editorial review, much as the inkprint copy of the book now does. The proposed editing box would take as input the original UNICON output, modify it according to editorial notes (also in BCD form) and produce a corrected stream of BCD characters for input to the Braille Translation box.

Nature of conversion

The conversion performed by UNICON cannot be quite so neatly categorized as that of TELCON. It is helpful, though, to describe two general types:

1. Simple substitution, whether one-to-one, or one-to-many;
2. Conversion which depends on scanning a stream of characters or a group of words.

1. Most input characters are converted by simple substitution. In the case of lower case alphabetic codes, numbers and some punctuation symbols, this is a one-to-one conversion. Some UNIVERSAL codes, mainly format codes, must be converted to more than one BCD code. For example, the single UNIVERSAL code 137 is converted to five BCD characters $PAR_. In either case, the substitution is accomplished by reference to a table and requires no scanning or analysis.

2. Of greater complexity is the programming necessary to handle capitalized or italicized information. Capital letters are uniquely represented in UNIVERSAL. In Braille, however, a single capital letter is preceded by a special code, a capitalized word, by a pair of codes, and a partially capitalized word requires the use of additional special codes. UNICON scans a word and supplies the appropriate codes where necessary.

A longer scan is required to provide the proper codes for italicized material. Input to UNICON is a 'Start Italics' code and an 'End Italics' code. The program determines whether the text between these two codes is three words or less, more than three words, or a series of paragraphs.

If there were no UNICON, each tape conversion box would have to perform the same kind of analysis to supply these composition codes. This function of UNICON - the elimination of redundant programming - should be kept in mind when writing additional tape conversion boxes. For example, TELCON determines whether a single right quote is really a single, half of a double quote, or an apostrophe. Should this same analysis be required in other tape conversion boxes, this bit of programming should become part of UNICON.

Flow

The nature of the input code determines the flow within the UNICON box. Some UNIVERSAL codes - usually format codes - can be converted and output immediately. In most cases, however, it is necessary to collect a stream of characters until a space code is encountered before putting out the equivalent BCD codes. The proper capital signs can be determined after scanning a single word. Following a 'Start Italics' code, it may be necessary to collect three words before anything can be put out.

Table

A table is required only for the conversion of UNIVERSAL codes in the '100' series. (See Appendix) Those codes lower than 100 are converted from UNIVERSAL to BCD by dropping the leading 0. The upper case codes, beginning with 4, are converted to BCD by stripping off the 4. However, codes in the 100 series must either be translated into a stream of BCD characters (137 into $PAR_) or must be used to influence translation of subsequent codes (e.g., $1\overline{4}1$, 'Start Italics').

The proper entry in the table is located by using the UNIVERSAL code as an index to the table. In most cases, the entry contains the BCD equivalent of the code and the address of the subroutine which handles the conversion. Where there is no BCD equivalent, only the subroutine address is included. At present, not all codes in this series are used. However, additions to the code, and thus to the table can be made very simply. Also, modification of the code to an eight-bit pattern - which might be desirable for another computer - is a simple matter. The basic structure of the UNICON box would be unchanged.

D. BRAILL

The function of this box is to convert a stream of BCD codes into Grade 2 Braille according to the official rules.(2) While the BRAILL box was written specifically for the 7094, and to conform to the 'box' requirements, the translation approach is based on that of the original 704 program. In this section, the nature of the conversion, the table organization, and the analytic routines are described only in general terms. For further details, see Ref. (3), especially Section III.

Input

Input to this box is a stream of BCD codes, most of which represent text material, and some of which are special format codes. (A partial listing of format codes is shown in the Appendix). For the demonstration programs this box was 'hooked' to UNICON and received its input from that box. It can also accept keypunched input, or input typed on the 1050 console.

Output

The BRAILL box puts out an eight-bit code which is an expanded Braille code. Six of the bits represent the Braille dots. The seventh serves as a parity check and the eighth is used for codes which control the embossing equipment (e.g., carriage return, line feed, etc.) Some of the codes put out by this box are neither Braille or control codes, but pseudo-codes which are interpreted by the FORMAT box. Output from this box is a stream of codes with no line-ending or page-ending indicators. For the demonstration programs, two versions of the FORMAT box were hooked to BRAILL. One of these produced input to the high-speed Braille embosser; the other, input to the card controlled stereograph equipment.

Nature of conversion

The nature of the conversion performed by the BRAILL box varies depending on the type of input received. The BCD codes for the text are converted to the expanded Braille code, either one-to-one, one-to-many, or many-to-one. However, the special format codes are converted to pseudo-codes and the final translation of these is handled by the appropriate FORMAT box.

The conversion of text material - especially the contraction of several BCD codes into one (sometimes two) Braille code(s) - is the most difficult problem and accounts for the largest part of this box. The complexity of the problem is illustrated by the discussion of the Braille rules in Section I. Even that partial list of rules points up the variety of restrictions which surround the use of contraction codes.

The rules, of course, were written for human transcribers and are stated in terms which are not always amenable to handling by a computer program. The conversion process described in this section is in computer terms. It does not depend on such'un-programmable' terms as 'sense' or 'meaning'. In some cases, rules which include these terms have been reformulated so that an analytic subroutine can determine the legality of the contraction. When this cannot be done, dictionary entries restrict the use of a contraction within a particular word.

The conversion of text material may be described under three different headings:

1. The contraction of several BCD characters, within a word;
2. The elimination of the space between one word and another;
3. The insertion of extra codes, producing a one-to-many conversion.

1. The first type of conversion accounts for the largest part of the Braille box, because of the many restrictions which limit the use of contraction codes. The use of a contraction code may depend on its position within the word, on the pronunciation of the word, or on a combination of both.

An example of the position only restriction is the following:

> The ... contraction COM may be used at the beginning of a word...but it need not be a syllable. It must never be used in contact with a hyphen, dash, or the apostrophe (2)

This restriction is easily programmed. When the COM sequence is encountered, a sub-routine tests whether it is preceded by a space or initial punctuation, and whether it is preceded or followed by the hyphen, dash, etc. This routine makes use of a 'rules' word stored in a table with the COM sequence and the Braille contraction code. This word defines the characteristics of the entry and of the codes which may not precede this contraction. In this case, and in most others, two comparisons must be made before the legality of a contraction is established. The COM segment (or 'bite') of the word is compared to whatever precedes it. If that sequence is legal, the COM contraction is accepted temporarily. The final decision about its use is only made when the bite following COM is evaluated.

Some contractions "must be used as parts of words wherever the letters they represent occur" but "should not be used where they would obscure the recognition or pronunciation of a word." (2) For example, the GH contraction may be used in the words GHetto, dinGHy, and touGH, but may not be used in the word foghorn. The pronunciation restriction is handled primarily by dictionary entries, since the vagaries of English pronunciation do not easily lend themselves to programmed analysis. Wherever possible, the entries are designed to govern the translation of more than one word. Thus, the single entry GHORN assures the correct translation of all forms of such words as FOGHORN, LONGHORN, BIGHORN, etc.

A third restriction, based on both position and pronunciation, is illustrated by the following rule:

> The contractions BE, CON, and DIS may be used only as syllables at the beginning of a word. (2)

Proper application of this rule requires a combination of dictionary entries and analytic routines. The correct translation of the word 'amber' is effected because the 'rules' word stored in the table entry for BE limits its use to the beginning of the word. However, the use of this contraction in the word 'benediction,' while meeting the position requirement, violates the pronunciation restriction. For this reason, there is a table entry for the letter combination BENE, which serves to translate a number of such words whose pronunciation forbids the use of the BE contraction (e.g., benefactor, benefit, etc.)

2. The second type of conversion - which includes space elimination - is illustrated by the following rule:

> The word signs a, and, for, of, the and with should follow one another without a space between if there is no natural pause between them...They should not be written together when punctuation signs or composition signs occur between them. (2)

The contraction of these words poses no problem since they should always be contracted when used as whole words. Furthermore, the punctuation sign restriction is easily handled by the rules routine. However, how can a computer program determine whether there is a 'natural pause' between two words? Analysis of these words in terms of part-of-speech shows that certain sequences seem to 'go together' while others are distinctly awkward. For example, the rules routine eliminates the space in the conjunction - preposition sequence (and with, and for) but not in the reverse sequence (with and, for and).

3. The third kind of conversion is an expansion, made necessary in part by the contraction rules. Because the single Braille code for most letters of the alphabet is used as a contraction code for a word when it stands alone (b = but, q = quite, etc.) the inkprint 'b' standing alone cannot be converted to the Braille 'b'. To distinguish the single letter from the whole word contraction, it is necessary to insert a letter sign. The analysis performed by the rules routine is essentially the same as that for position restrictions; the result is that two Braille codes are output for a single input code.

Flow

In general, the basic translation unit is a word - that is, the characters between spaces. Therefore, the BRAILL box collects a stream of BCD codes, up to and including a space code. After reference to the table and analysis of the rules routine, the Braille codes are usually put out. However, if the rules so indicate, the succeeding word or words may have to be collected before any Braille is output.

Although the conversion of format codes does not require the same analysis as text material, the program flow is the same. Each of these special codes is a stream of BCD characters, the first of which is a $, the last, a space code. The table search yields one or more pseudo-codes which are then put out, just as the Braille codes.

Table

Two tables are utilized in the translation process. The Grade I table is of fixed length and contains a two-word entry for each BCD character. The Grade 2 table is variable in length and can be expanded to handle new problem words or letter combinations as they are encountered.

The Grade I table serves two purposes: to handle the one-to-one conversion, and to speed the search of the Grade 2 table. Each entry in that table contains not only the Braille code for a given BCD character, but also an index which 'points to' the first word in the Grade 2 table which begins with that letter.

In addition to entries for each of the contractible letter combinations, the Grade 2 table contains entries for words or parts of words which are exceptions. The table is arranged alphabetically, but the blank is considered the highest code. Thus, unlike the standard dictionary, the word THESE preceedes THE. This insures that the longest combination or 'bite' will be found first. Were they reversed, the word would be incorrectly translated into the contraction THE, followed by S and E, instead of the special contraction code for THESE.

Each table entry, whether Grade I or 2, also contains a rules word which describes the entry and the conditions which restrict its use. Thus, the rules word for the 'b' entry in Grade I includes an indicator that a letter sign must be inserted if this letter stands alone as a whole word; and the rules for the BE entry in the Grade 2 table indicate that this contraction may only be used at the beginning of a word. A word is not correctly translated until every bit (letter, or letter combination) has been evaluated by the rules routine and found to be legal.

E. FORMAT

The function of this box is to arrange the Braille codes in the format required by the embossing equipment. Two versions of this box have been demonstrated. The differences between them were determined by the two types of Braille-producing equipment used.

Input

Input to FORMAT is the stream of eight-bit codes described in the BRAILL - Output section. There are two types of codes: those which represent the Braille cells, and pseudo-codes which control the formatting of the Braille material.

Output

The output of FORMATI is a stream of Braille and control codes arranged to drive the M.I.T. high-speed embosser.

This paper tape driven embosser requires a line of exactly 38 Braille cells to position the next embossing head correctly at the beginning of a line.

This version of FORMAT insures that a complete word ends each line and, when necessary, supplies spaces to produce a 38-cell line.

While the embosser produces continuous lines of Braille on a paper roll, it was decided, for the demonstration, to space the paper three lines after each 25 lines of Braille to indicate a rough form of pagination.

Headings or titles are centered by preceding and following the Braille by the number of spaces required to create an entire line.

FORMAT1 also rearranges the parity and control bits to conform to the coding scheme used on the embosser.

The second version of this box, FORMAT2, is designed to produce output fro the card-controlled stereograph machines at the American Printing House for the Blind. This equipment embosses an interpointed zinc plate which is used for volume production.

The stereograph does not require a line of fixed length. Any number of cells up to a maximum of 38 is permitted. Carriage return and line feed codes control the positioning of the single embossing head. An end-of-card code signals the card reading mechanism to eject the current card and proceed to the next. An end-of-page code stops the stereograph to allow the operator to turn or replace the zinc plate.

Centered material is handled by preceding the Braille with the proper number of spaces, and following the Braille by an end-of-line code.

The parity and control bits output by the BRAILL box need not be rearranged.

Nature of conversion

Within this box codes may be converted one-to-one, one-to-many, or one-to-none. In some cases there is no conversion.

FORMAT1 performs a minor conversion (rearrangement of the parity and control bits) on every Braille code, but FORMAT2 does not. In either case the Braille codes are counted and saved. When a space is encountered, a check is made to see whether a line has been filled or exceeded. If so, control is given to a routine which outputs a line.

An example of a one-to-many conversion performed by both versions of FORMAT is a 'start centering' pseudo-code. This will produce the number of space codes necessary to left indent the Braille line properly. In some cases the same code may be converted one-to-many by FORMAT1, but not by FORMAT2. The most obvious example is an unconditional end-of-line code which may be converted to several spaces by one box, or to a single end-of-line code by the other.

Certain codes may produce no output. These are called 'conditional' codes, and whether a corresponding code should be output is determined by the conditions (line length, page length, etc.) at the time the code is read.

Flow

As each character enters this box it is checked to determine whether it is a Braille code or a pseudo-code. Braille codes are placed in a list and saved until one line is collected. Each pseudo-code causes a transfer to a specific subroutine. Each of these small routines makes a decision based on certain indicators and takes appropriate action.

For example, the BRAILL box converts $PAR_ into the following pseudo-codes:

350,260,303,303

350 is a conditional end-of-line code; it may not begin a line. The appropriate subroutine examines the line pointer to see if it is pointing to the first character of the line. If it is, no action is taken and the next character is read. If the pointer indicates that there are some Braille codes waiting to be put out, the line is ended either with the proper number of space codes or with an end-of-line code and the entire line is passed along.

Another routine converts the 360 pseudo-code into an end-of-card code which will cause this card to be ejected by the card reading device which controls the stereograph.

The two 303 codes, unconditional space codes, are converted to Braille spaces and placed at the beginning of the line.

Thus, the effect of the $PAR_ code is: to end a line if there is one waiting, to end the current card, and to put out two spaces to indent the next paragraph.

F. OUTBOX

The function of this box is to interface with the input/output system of CTSS and produce disk files of appropriate format which can be punched off-line. The resultant card files may then be used to drive the card-controlled stereograph (OUTBOX2) or further processed to produce a paper tape to drive the M.I.T. embosser (OUTBOX1).

Input

Input to OUTBOX is a stream of Braille and control codes necessary to produce properly formatted Braille on embossing equipment.

Output

Output from this box is a disk file in punched card format.

Flow

OUTBOX fetches and saves codes until it has enough to create a card image. OUTBOX1 creates a BCD card image with three numbers for each Braille code. A single card (columns 1 - 72) contains 24 Braille codes. OUTBOX2 creates a binary card image with a complete Braille code (or control code) in each of the columns 8 - 72.

G. UTILITY ROUTINES

During the testing of the system, it quickly became apparent that certain utility routines would be of enormous value. These small boxes are concerned with console input/output in various formats.

TYPEIN

This box accepts a line of input from the 1050 console and outputs one character at a time to whatever box is hooked to it. When it receives the break character it generates an end-of-line code.

TYPOUT

Input to TYPOUT is a binary number up to nine bits long. It converts the number into a format suitable for typing on the console, saves enough of these codes to make up a line, and then outputs one line at a time.

UNITYP

This box, designed to print the results of UNICON, types BCD codes on the console typewriter.

DOTPR

This box creates a printed representation of Braille on the console typewriter by typing a series of dots. Input is the eight-bit Braille code described in the BRAILL output section.

V. APPENDIX

A. Teletypesetter Code

Tape Image

Channel Numbers 5	4	3		2	1	0	Unshift		Shift
			•					Tape feed	
o			•				t		T
	o		•					Return	
o	o		•				o		O
		o	•					Space band	
	o	o	•				n		N
o		o	•				h		H
o	o	o	•				m		M
			•	o				Elevate	
		o	•	o			i		I
	o		•	o			r		R
	o	o	•	o			c		C
o			•	o			l		L
o		o	•	o			p		P
o	o		•	o			g		G
o	o	o	•	o			v		V
			•		o		e		E
			•	o	o		a		A
		o	•		o		s		S
		o	•	o	o		u		U
	o		•		o		d		D
	o		•	o	o		j		J
	o	o	•		o		f		F
	o	o	•	o	o		k		K
o			•		o		z		Z
o			•	o	o		w		W
o		o	•		o		y		Y
o		o	•	o	o		q		Q
o	o		•		o		b		B
o	o		•	o	o			Shift	
o	o	o	•		o		x		X
o	o	o	•	o	o			Unshift	
			•			o		Thin space	
			•		o	o	3	?	3/8
			•	o		o		P.F. or L.M.	
			•	o	o	o	$		!
		o	•			o		Add thin space	
		o	•		o	o		Em space	
		o	•	o		o	8		-
		o	•	o	o	o	7	&	7/8

Teletypesetter Code - continued

Tape Image

Channel Numbers

5	4	3		2	1	0	Unshift		Shift
	o		•			o	'		'
	o		•		o	o	-		@
	o		•	o		o	4	*	1/2
	o		•	o	o	o		Bell	
	o	o	•			o		Comma	
	o	o	•		o	o		Quad left	
	o	o	•	o		o		En space	
	o	o	•	o	o	o		Q.R. or U.M.	
o			•			o	5	ff	5/8
o			•		o	o	)		(
o			•	o		o	V. rule		Em space
o			•	o	o	o	2	ffl	1/4
o		o	•			o		Em leader	
o		o	•		o	o	6	lb	3/4
o		o	•	o		o	0	fl	?
o		o	•	o	o	o		En leader	
o	o		•			o	9	fi	&
o	o		•		o	o		Upper rail	
o	o		•	o		o	;		:
o	o		•	o	o	o		Lower rail	
o	o	o	•			o		Period	
o	o	o	•		o	o	1	ffi	1/8
o	o	o	•	o		o		Quad center	
o	o	o	•	o	o	o		Rub out	

B. Universal Code

General Characteristics of Universal Code

Each character in the code is a distinct nine-bit number. This number is denoted by the three-digit octal representation of the binary number. This representation is henceforth called the character's octal code.

The high order digit in the octal code tells what kind of character this particular code represents. A high order 0 indicates digits and lower case letters. A high order 1 indicates punctuation or control characters. A high order 4 indicates upper case letters. All other digits are, as yet, undefined in the high order position.

TABLE OF CURRENTLY DEFINED OCTAL CODES

Octal Code	Symbol or Control Character
000	0
001	1
002	2
003	3
004	4
005	5
006	6
007	7
010	8
011	9
021	a
022	b
023	c
024	d
025	e
026	f
027	g
030	h
031	i
041	j
042	k
043	l
044	m
045	n
046	o
047	p
050	q
051	r
062	s
063	t
064	u
065	v
066	w
067	x
070	y
071	z

Table of Currently Defined Octal Codes - continued

Octal Code	Symbol or Control Character
421	A
422	B
423	C
424	D
425	E
426	F
427	G
430	H
431	I
441	J
442	K
443	L
444	M
445	N
446	O
447	P
450	Q
451	R
462	S
463	T
464	U
465	V
466	W
467	X
470	Y
471	Z
100	BLANK
101	HYPHEN
102	APOSTROPHE
103	SINGLE OPEN QUOTE
104	SINGLE CLOSE QUOTE
105	DOUBLE OPEN QUOTE
106	DOUBLE CLOSE QUOTE
107	GENERAL PURPOSE POINT
110	)
111	EXCLAMATION MARK
112	$
113	PERCENT SIGN
114	*
115	/
116	NUMBER SIGN
117	,
120	(
121	QUESTION MARK
122	ACCENT

Table of Currently Defined Octal Codes - continued

Octal Code	Symbol or Control Character
123	=
124	COLON
125	SEMI-COLON
126	AMPERSAND
127	DASH
130	OPEN BRACKET
131	CLOSE BRACKET
132	DEGREE SYMBOL
133	DECIMAL POINT
134	SECTION SIGN
135	PERIOD
136	PARAGRAPH SYMBOL
137	START PARAGRAPH
140	END LINE
141	START ITALICS
142	END ITALICS
143	START POETRY
144	END POETRY
145	START CHAPTER TITLE
146	END CHAPTER TITLE
147	START SUBHEADING
150	END SUBHEADING
151	START GRADE I BRAILLE
152	END GRADE I BRAILLE
153	SKIP LINE
154	RESERVE 5 LINES FOR TABLE
155	RESERVE 10 LINES FOR TABLE
156	RESERVE 15 LINES FOR TABLE
157	RESERVE 20 LINES FOR TABLE
160	RESERVE 1 PAGE FOR TABLE
161	RESERVE 2 PAGES FOR TABLE
162	RESERVE 3 PAGES FOR TABLE
163	RESERVE 4 PAGES FOR TABLE
164	RESERVE 5 LINES FOR FIGURE
165	RESERVE 10 LINES FOR FIGURE
166	RESERVE 15 LINES FOR FIGURE
167	RESERVE 20 LINES FOR FIGURE
170	PAGE NUMBERING

C. BRAILL INPUT (A partial list of symbols and format codes)

Capital Letters or Words

When an entire word is capitalized, precede the word by a double capital sign: = =. There should be no space between the capital sign and the first letter of the word.

When only the initial letter of a word is capitalized, precede the word with a single capital sign: =.

When a portion of the word is capitalized, the double capital sign is used to indicate the beginning of the capitalized portion. The end of the capitalized portion is indicated by $TC (Terminate Capital).

When the capitalized portion of the word begins in the middle, the hyphen should precede the double capital sign. When the final portion of the word is capitalized, the $TC is not required.

Examples:	DIStinguish	==$TCtinguish
	disTINguish	dis-==$TCguish
	distinGUISH	distin-==guish

Italics

When 1, 2 or 3 italicized words occur in sequence, precede each with a single italics sign: $I.

When 4 or more italicized words occur in sequence, precede the first with a double italics sign ($II), and the last with a single italics sign ($I).

When several italicized paragraphs occur in sequence, precede each paragraph with a double italics sign, and the last word of the last paragraph with the single italics sign.

When a portion of the word is italicized, the single italics sign ($I) is used to indicate the beginning of that portion, and $TI (Terminate Italics) is used to indicate the end. When the italicized portion is at the end of a word, the $TI is not required. (see examples under Capitalization)

Keypunch Symbols

Accent	$A
Poetry	$IPO
Period	.
Comma	,
Semicolon	=,
Colon	=.
Dash	--(8-4)
Question mark	$Q
Exclamation point	$X
Double quotes (left)	=(
Double quotes (right)	=)
Single quote (left)	+(
Single quote (right)	+)
Left parenthesis	(
Right parenthesis	)
Left bracket	$(
Right bracket	$)
Ampersand	AND
Apostrophe	$,
Asterisk	*
Degree symbol	$DG
Dollar sign	$DOL
Decimal point	$DEC
Ellipsis	...
Equals	$
Hyphen	-(8-4)
Number sign	$N
Paragraph symbol	$P
Percent sign	$PC
Section symbol	$S
Slash, fraction mark	/

Format Control Codes

$EL	End line
$SKIP	Skip one line
$PAR	Start new paragraph
$CHAP	Start new chapter; this code indicates the beginning of the chapter title
$ECH	Indicates the end of the chapter title
$IPO	Initiate poetry format
$TPO	Terminate poetry format
$HEAD	Indicates the start of a subheading
$HDEND	Indicates the end of subheading
$RTLn	Reserve n lines for table
$RTPn	Reserve n pages for table
$RFLn	Reserve n lines for figure or diagram
$IGI	Initiate Grade I (letter-for-letter) translation
$TGI	Terminate Grade I translation
$PAGNO	Indicates page number references in text; should be punched in place of the number shown

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BRAILLE EMBOSSER AND DISPLAY SYSTEMS

Professor Dwight M. Baumann

The sensory aids work in the Engineering Projects Laboratory (Mechanical Engineering Department at M.I.T.) began in 1960 with a small grant from the American Foundation for the Blind.* The grant was utilized to buy some equipment for a few undergraduate student projects directed towards enhancing the availability of Braille. At that time basic planning was begun on what has developed into the device known as the M. I. T. Braille embosser. Through utilization of student projects, basic studies were made of the force required for embossing paper and zinc plates, and investigations were made of the feasibility of connecting a Braille embosser to a standard office typewriter as a driving source.

Early in the program there was considerable discussion about the state of the art, problems of producing devices for the handicapped, and some of the needs particularly relevant to the blind community. The discussions were led by Mr. John Dupress, then with the American Foundation for the Blind, who set up a monthly sensory aids discussion meeting at M. I. T. These meetings, a monthly event, are still being held and are a focal point for the local sensory aids research activities.

At the outset of the sensory aids discussions, it became evident that there had been no systematic investigation of the problems of developing sensory aids devices. What was needed was a systems approach to the problems of developing technological solutions to the sensorily handicapped. While there were some devices - various Braille embossers, canes, etc., and a well developed and standardized Braille language - there seemed to be a large number of unanswered technological questions about the application of the newer computer and data processing techniques to the production of Braille. Perhaps more significantly, there was the feeling that our present state of technology might be able to supply some new understanding and perhaps even some new, radical, more efficient methods for communicating with the sensorily deprived.

One of the most blatant discoveries was finding that there was a tremendous shortage of good engineering and development in the sensory aids field. Across the country small groups were at work, many with only volunteer labor, developing or perfecting various individual devices. What became apparent as the greatest lack, however, was that there was no effective "market place" activity to spur the conversion of the prototype gadget into an off-the-shelf item that a needy person or a public or private agency could purchase. Fortunately there isn't as much need for all classes of sensory aids as there is for eyeglasses or hearing aids, and thus there is not the promise of a hugh market; and also perhaps there is enough public good sense not to exploit financially those who could be aided by such devices.

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* Since about 1961, all of the work reported here has been sponsored by the Vocational Rehabilitation Administration (formerly OVR), Department of Health Education and Welfare.

The need, then, was to find a mechanism whereby everyone from the basement gadgeteers to the formal research and development centers could take their devices for independent testing, evaluation, and (if successful) then development of sufficient prototype copies for effective evaluation of the success of the device. Thus the need was perceived to develop the Sensory Aids Evaluation and Development Center, of which Mr. Dupress is now the Managing Director.

As I have suggested, the need of our sensorily impaired population is a mechanism for investigating devices, even those that have not yet been developed to the point where they work reliably, finding out which ones are good, which ones are better, and what needs they could supply. We suspect there are probably no devices that are universally best, just as there is not really a "best" automobile - although there seem to be "best" automobiles in in the beholder's eyes - so we feel there will be a range of best devices and that they will depend very largely on the users. But somehow this range of better devices needs to be made available.

When, in 1960, we heard about work being done in other places, we found some very sad instances where things had been developed to a certain stage and then left. For example, back in 1955 or 1956, a Dr. Witcher, whom you may have heard of, worked at the Research Laboratory of Electronics here at MIT on a photocell probe that sent back an audio signal; devices were built and tested. Blind people could use them to walk down the hall and to find lights; they could even do some rough scanning of newspaper headlines and read meters and oscilloscopes. This so-called Audio-Viz Probe had been completed by Dr. Witcher and he built his own prototype. He got sufficient funding to have about 30 of them built. Unfortunately, Dr. Witcher died and the Audio-Viz Probes were stored away in a box for a number of years. It wasn't only because no one knew what they were, but also because the devices were not quite correct. In other words, they should have gone back to the manufacturer to be straightened out. Out of the boxfull, only a couple of them worked really well. But there was a discontinuity in this process of turning the device that somebody made with a lot of sweat and a lot of overtime hours into the production prototypes where you finally have some that can be given to people for use in their work. I think this is only an example of a national problem; I think this is something we ought to concern ouselves with very much today in our discussions. The approach we have taken at M.I.T. is to instigate the Sensory Aids Center, and you will hear more about this in the discussions, I am sure.

Now, let's talk about some of the devices. Professor Ted Glaser was implying that some of the work he's associated with is part of a larger project on the development of time-shared computers. In a sense, what is going on is that the sensory aids activities, the work for the blind, is harvesting the fall-out of space technology in a real sense by taking place right at the place where the actual space and communication science work is going on. We perhaps will make the most significant changes in what is available to the blind and to the deprived of all kinds of harvesting this fall-out, here and everywhere. We have heard from Mr. Morrison that what he is really doing in the information area is harvesting the fall-out of the telephone technology.

Here is a keyboard that Ted mentioned just briefly. These are push-button modules primarily built for the computer business. This keyboard will be the one-handed - two-handed keyboard, and can be used with either our Braille embosser or on line-at-a-time Braille displays. The keyboard consists of a standard row of six keys of the basic Braille keyboard and the space bar. There are four keys across the top that are the function keys, and a special key that activates dots 2 and 3, and one that activates 5 and 6. (Ray Morrison: "That's similar to the one made in Italy." Prof. Baumann: "Yes, this is just one version.") What we are doing is plugging the basic switch modules around different ways. These are micro switches and they are standard items at this time. This entire keyboard is about a $100 item - bought at commercial rates right now.

This is a diagram by Professor Mann* that shows the entire system that can be used for enhancing the availability of Braille. I have a few copies that we can pass around, and some of you may want to have them. Basically, there are a number of systems that need to be developed. Several need to be used together for the different purposes. Since there is no scientific reason why Braille should not be available at the same time a printed book is, we have been concerning ourselves with some of the more significant device requirements needed to carry out the plan of automatic production of Braille from teletypesetter and monotypesetter tape to embossed Braille 2.

Mr. Goldish probably told you something about some of these types of projects. We see that there is a need for Braille in several forms; we see that there is sometimes an instantaneous need and there is sometimes a need that one can afford or be willing to wait for a day, and sometimes there are needs that one can afford or wait for a week or a month. Professor Glaser mentioned to you the kinds of systems we're talking about, if we need instantaneous availability of Braille. For these needs we would require a centralized small computer that one can call on a telephone line and have an immediate translation into a form of Braille. We have also on this chart some mechanisms for producing the book plates, or the zinc plates, the Braille tapes; and there is now a standard Braille tape and other tape output devices.

One of the devices that was investigated was a ball bearing display. This is a moving belt display, but the paper tape actually is used to meter out small ball bearings into a perforated metal tape, and run them across under the finger.

This device has a ball feeder in the top which is loaded with a cupful of balls that are fed into a metal tape which has holes punched in it in all the possible (Braille cell) dot positions. The finished paper tape actually lets the balls drop through it to fall into position to be captured by the metal tape.

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* To be available in Engineering Projects Laboratory Report No. 70249-1, "Enhancing the Availability of Braille," M.I.T.

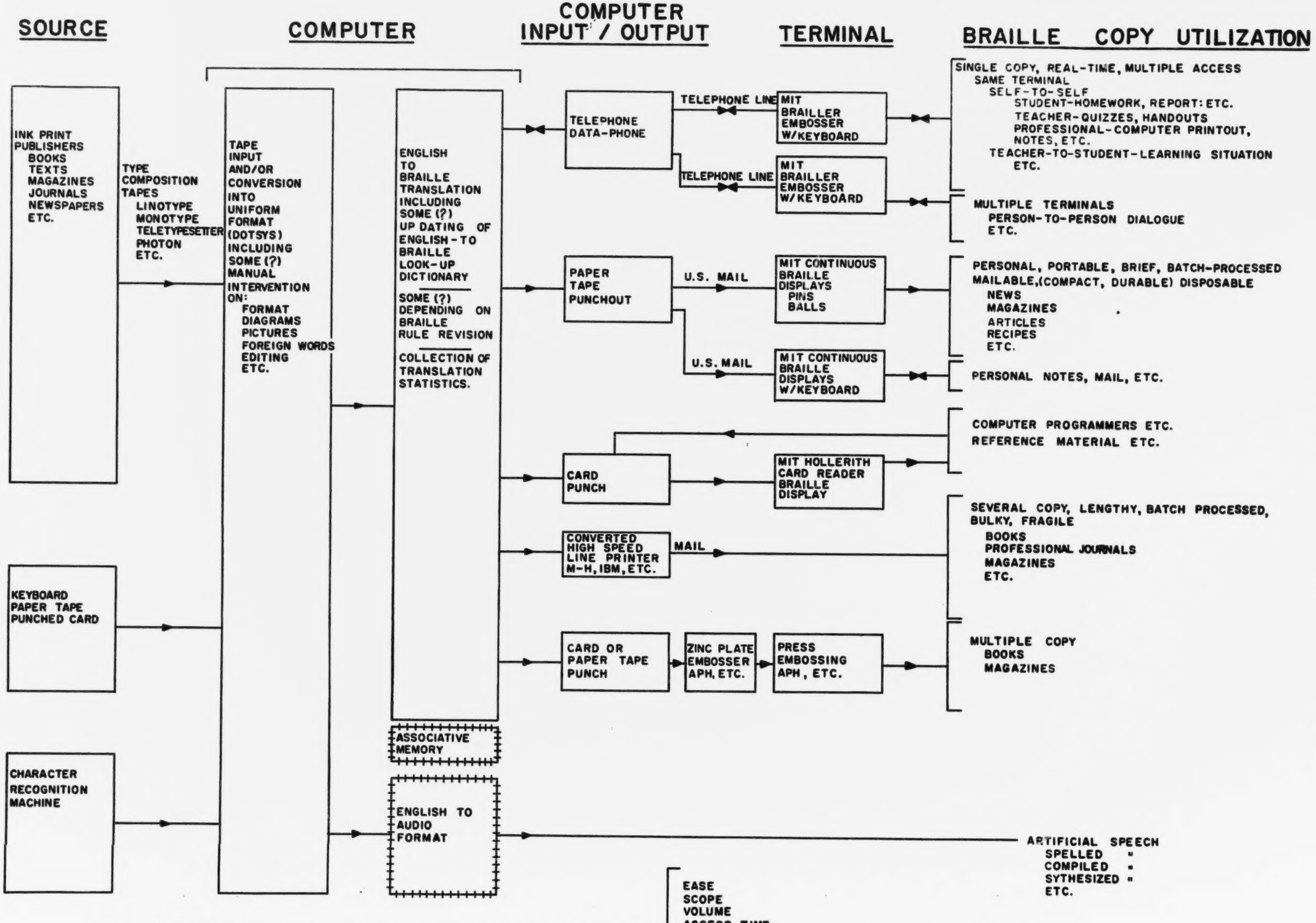
SOURCE
COMPUTER
COMPUTER INPUT / OUTPUT
TERMINAL
BRAILLE COPY UTILIZATION
INK PRINT
PUBLISHERS
BOOKS
TEXTS
MAGAZINES
JOURNALS
NEWSPAPERS
ETC.
TYPE COMPOSITION TAPES
LINOTYPE
MONOTYPE
TELETYPESETTER
PHOTON
ETC.
KEYBOARD
PAPER TAPE
PUNCHED CARD
CHARACTER RECOGNITION MACHINE
TAPE INPUT AND/OR CONVERSION INTO UNIFORM FORMAT (DOTSYS) INCLUDING SOME (?) MANUAL INTERVENTION ON:
FORMAT
DIAGRAMS
PICTURES
FOREIGN WORDS
EDITING
ETC.
ENGLISH TO BRAILLE TRANSLATION INCLUDING SOME (?) UP DATING OF ENGLISH-TO BRAILLE LOOK-UP DICTIONARY
SOME (?) DEPENDING ON BRAILLE RULE REVISION
COLLECTION OF TRANSLATION STATISTICS.
ASSOCIATIVE MEMORY
ENGLISH TO AUDIO FORMAT
TELEPHONE DATA-PHONE
TELEPHONE LINE
TELEPHONE LINE
MIT BRAILLER EMBOSSER W/KEYBOARD
MIT BRAILLER EMBOSSER W/KEYBOARD
PAPER TAPE PUNCHOUT
U.S. MAIL
U.S. MAIL
MIT CONTINUOUS BRAILLE DISPLAYS PINS BALLS
MIT CONTINUOUS BRAILLE DISPLAYS W/KEYBOARD
CARD PUNCH
MIT HOLLERITH CARD READER BRAILLE DISPLAY
CONVERTED HIGH SPEED LINE PRINTER M-H, IBM, ETC.
MAIL
CARD OR PAPER TAPE PUNCH
ZINC PLATE EMBOSSER APH, ETC.
PRESS EMBOSSING APH, ETC.
SINGLE COPY, REAL-TIME, MULTIPLE ACCESS
SAME TERMINAL
SELF-TO-SELF
STUDENT-HOMEWORK, REPORT: ETC.
TEACHER-QUIZZES, HANDOUTS
PROFESSIONAL-COMPUTER PRINTOUT, NOTES, ETC.
TEACHER-TO-STUDENT-LEARNING SITUATION
ETC.
MULTIPLE TERMINALS
PERSON-TO-PERSON DIALOGUE
ETC.
PERSONAL, PORTABLE, BRIEF, BATCH-PROCESSED
MAILABLE, (COMPACT, DURABLE) DISPOSABLE
NEWS
MAGAZINES
ARTICLES
RECIPES
ETC.
PERSONAL NOTES, MAIL, ETC.
COMPUTER PROGRAMMERS ETC.
REFERENCE MATERIAL ETC.
SEVERAL COPY, LENGTHY, BATCH PROCESSED, BULKY, FRAGILE
BOOKS
PROFESSIONAL JOURNALS
MAGAZINES
ETC.
MULTIPLE COPY
BOOKS
MAGAZINES
ARTIFICIAL SPEECH
SPELLED "
COMPILED "
SYTHESIZED "
ETC.
EASE
SCOPE
VOLUME
ACCESS TIME
AUTOMATION
COST

FIG. I ENHANCING THE AVAILABILITY OF BRAILLE

R.W. MANN

MAY 25, 1966

Another mechanism that was tried earlier consists of a mechanism that pulls in a strip of tape while lifting a platen with a set of pins and then, when the tape is pulled in, it brings the platen down, and all the pins that fall through the holes don't stick up. Only the ones that are in places where there is paper are trapped and therefore must stick up. On this device a new line is produced each time the tape advance lever is moved.

Professor Blanco (now at Tufts University) is working on a related version which sets a continuous row of Braille. Again, it uses the paper tape to stop the pins from dropping down and is read on this bottom surface, but in his device the platen is a segmented continuous belt.

Our most ambitious project is what has come to be known as the M.I.T. Braille Embosser. It is a high-speed Braille embosser that has the capability of going up to around 18 characters per second, which is faster than an IBM Selectric typewriter. It does not require carriage return, for reasons which I'll show you, and therefore Ted Glaser has the fastest terminal now in use on a computer. The embosser has been built both as a table-top model and as a free-standing console that is analogous to the familiar teletype console. Professor Glaser has one of the Braille consoles coupled to his PDP-8 computer.

In actual operation of the M.I.T. embosser, there are three heads on a continuous chain so that as the first head sweeps past and comes to the end of the line, there is another head starting the line. The device, therefore, does not require a carriage return. The heads have an interposer device which is pushed in from the side, and that makes the pins stiff (when the interposer is pushed in, the pins are stiff). Otherwise, they will depress. The platen on top of the embosser simply oscillates up and down, so all the power comes from the platen.

The M.I.T. embosser is a combination of electronics and mechanics, in that for some of the logic operations one needs to perform it is less expensive to use mass produced electronics than to develop special purpose mechanical decoding devices. The circuit is a standard transistor circuit and eventually we expect to have this in an integrated circuit form to further cut the cost and complexity, and to increase reliability.

Now I would like to talk quickly about some of the other things that are going on. Phil Blackman is a Research Assistant working on the completion of a prototype line-at-a-time display system which is essentially the Braille equivalent of a slate and portable dictation machine. It has the capability of taking punched paper tape (fan-fold punched paper tape) and presenting a Braille belt display. The belts are very similar to the kind used by Dr. Whitcher in 1955 and 1956, except we have been working on various kinds of belts and mechanisms for reading the paper tape, and in turn for reading back from the belt in settings to make up a punched paper tape. In this later mode a line can be composed, proofread, and then entered into the punched paper tape mode. We are expecting a highly portable device that will read paper tape, punch paper tape, and yet be roughly the size of a book, so it can be carried under the arm. The feature that sets the pins from the keyboard and then, when we approve of that row and push the button, punches it out onto paper tape, will be most useful in setting up mathematics or for writing poetry or notes of various kinds. The keyboard will be a version of the one-handed - two-handed keyboard, so that it can be used readily in the abstracting of notes sensed by one hand, while the other is used for reading. There will be the keyboard above the belt display and the fan-fold paper tape magazine on the side. It uses fan-fold paper tape so that you can get to the middle of a stack of paper tape.

Recently completed is a doctoral thesis looking at some memory devices that are particularly relevant to the dictionary look-up problem that has been alluded to this morning. In particular, we are looking at a mechanism for developing an associative memory using optics. Now an associative memory is a memory where you don't have to scan through the memory to find a particular entry, but rather someone has made the analogy. It is like saying to the needle in the haystack - needle, come forth. It doesn't require that you search through all the straws to find the needle; rather, you simply present the data to the memory and if it has in it that entry, it gives out a spot of light which eventually will, we hope, allow us to put a code at that spot of light, which is the equivalent Braille word or the equivalent output from the memory device. This holographic, layer-driven associative memory is quite basic work. We are not yet close to the hardware for the final memory development, but it is, again, looking at ways to build "read only", large capacity dictionaries which would allow one to do the full Grade 2 conversion in a very small piece of apparatus.

ADVANCES IN BRAILLE EMBOSSING

Ray E. Morrison

I am going to show you a few things that others may not demonstrate. I am interested in Braille embossing from a technical viewpoint, as I am an engineer.

First, something that I ran across that might interest you who make illustrations for textbooks for Braille instruction to sighted people. This is a method of producing inkprint Braille with the use of a Varityper; Mr. Humphry of New York developed the method. As you probably know, with the Varityper the type face can be changed easily. One of the type fonts has a heavy dot which can be used to illustrate the embossed Braille dot and the period - a light dot - for the cell positioning dots. In this way the Braille cell can be illustrated in inkprint.

Here are some samples to show how it is done. First, with a sheet having the positioning dots across the page, the heavy dot for the Braille embossing is marked in the cell by hand. Then, with the Varityper, the embossed dot and positioning dots are typed in a line at a time. The other two lines of a cell are printed in a similar manner.

I'll admit this is rather involved but, as you can see, it produces a good illustration of inkprint Braille. Another feature is that the English text can be typed underneath. The sheets can be reproduced by various methods for textbook illustrations.

Another thing I have here is a handout describing a method of transmitting Braille to various locations. As Mr. Goldish explained, we could use tape or transmit "on line" from the keyboard. As you probably know, we in the Bell System are interested in transmitting information from one location to another by teletypewriter or other means. My system transmits the actual Braille signal from here to there. The Library of Congress is the control repository for Braille information. They could have a file of Braille on tape. These could be made in several different ways. Dr. Woodcock, this afternoon, will show one way to produce them. He has one system, I have another - friendly competition, you might say.

Coding is illustrated on the second and third sheets of the handout. It was standardized a year or so ago, so the Braille code would correspond to the American Standards Code for Information Interchange (ASCII). Braille cell information is represented in levels one through six with a control code in position seven (such as carriage return and line feed) and "even parity" in the eighth position for machine and error verification. Dr. Woodcock's machine produces tape with this coding; we are trying to standardize it so we all can talk together.

Several different keyboard configurations have been developed. My layout is shown on the second page. Since I have no machine shop facilities, I had to use a standard teletypewriter and modify it to produce Grade 2 Braille. To illustrate: there are 17 characters in Grade I to which a dot 6 can be added to give a Grade 2 contraction. For instance, "a" is dot I (one), while "ch" is dots I and 6. Also, Braille numerals are the first ten letters of the alphabet preceded by a "number sign", so their place on the standard machine can be used for Braille punctuation signs. In this way the full Grade 2 can be made with a standard machine as modified. However, one does not have to know Grade 2 Braille to operate it as it will transmit Grade I as well. Dr. Woodcock this afternoon, will show his version The layout is just personal preference. One of these days the layout will be standardized.

Here is something that hasn't been demonstrated to date, that I know of. It is an automatic tape brailler. To illustrate its use - the AP/UPI newswire types the news on a "hard copy" printer. My equipment is auxilliary to the printer and embosses Braille off the signal on a tape like the Banks brailler. Thus, a blind person can "read" the news or stock ticker results without an intermediate transcription. As an added feature, since this is on tape, the end of line carriage return and line feed have no effect on the embossing. On a page Braille embosser, this could cause difficulty since the Braille line has 38 cells and the page printer 72.

The heart of the system is a Braille diode matrix to convert the regular teletype signals to Grade I coding. The tape embosser is a standard unit modified to emboss rather than perforate tape. Although this is a Grade I system, it will help a lot of people.

If interested, I'll give you more details. Thank you.